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SPECIAL ISSUE ON TROPICAL PINES—PART I

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(A Monthly Journal of Forestry and Forestry Research)

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Speech delivered by Prime Minister Smt. Indira Gandhi on the Centenary Celebrations of Forest Education in India held at Forest Research Institute & Colleges, Dehra Dun on December 19, 1981.

Ladies and gentlemen,

I am glad to be with you on this occasion. Trees have been important in my life since my earliest childhood. Almost, as soon as, I could walk I was climbing trees, hiding in their branches when I wanted to escape the grown-ups, and later as a refuge for study and reading.

How cool trees look in the heat and how essential is their shade for us! Few sites are more beautiful, than trees whether in flower or with their branches laden with fruit or just the countless variety in shape and colour of leaf and of the tree itself. *Trees are amongst man's most reliable friends and a country which cares for its future must take good care of its forests.*

Time was when Mussoorie was known as queen of the hills. Dehra Dun blossomed and shared in her glory. She has now been robbed of her garment. Her climate has changed, her beauty has gone. *It is indeed sad how our hillsides in all parts of India are becoming bare and brown.* In the South the Nilgiris got their name because of their rich tropical forests deep blue-green in colour. But, little by little and specially during the Second World War and after, the hills were denuded of their tree cover.

This is happening also on our Himalayan slopes. *The contractors' axe and human greed are destroying our forests, causing great ecological damage, erosion and floods and depriving many of their traditional livelihood. Europe is much more industrialised than we. Yet most, if not in all the major cities they have forests either within the city or closeby.* Fortunately, of late, there has been some reawakening of popular interest in and recognition of the vital importance of forests. A new breeze is blowing amongst forestry professionals. Experts have introduced new concepts like high-yielding forestry, intensive management of production forests, conservation of national ecosystems, urban forestry, photointerpretation, the mapping of forest resources, logging training, wild life management and so on.

Specialisation is inescapable in our age of advanced technology but how can it yield the desired results unless it fits into the overall social situation in our country? *Our forests can survive only if forestry is attuned to the goals of national development, and long-term ecological welfare as well as that of the communities which live nearby.*

New insights and a sense of urgency combined with responsibility must be infused in our forestry policy and education. Ecological conservation can become a reality when the people's needs for fuel and employment are satisfactorily met. As the frontiers of forestry are enlarging, foresters must come out of their self-imposed boundaries of reserve forests and think of wood lots, social forestry and other techniques to involve the community itself.

We must ensure that social forestry does not replace valuable old forests. I see no conflict between the two. New forests should be planted and where there is space in old forests different types of new trees can be put in. The development of agriculture and industry and the high growth of population continue to reduce our per capita forest area. This has a spiral effect on forest resources. Forests are a traditional renewable and cheap source of energy for rural people. The skyrocketing increase in the price of petroleum products has led to a greater onslaught on our forests. Rural people want wood for domestic energy and manufacturers want it for industries like paper, pulp, plywood, safety matches, sports goods etc. But the simultaneous increase in demand for food crops, fodder crops, cash crops like jute and cotton and plantation crops like rubber, tea and coffee along with inroads made by hydro-electric works, townships, railways, roadways, canals, power transmission lines, mines etc., make it extremely difficult to extend the forest area. But some balance must be found by weighing the relative importance of programmes.

Production must be augmented by improving productivity by using science to solve the problems created by development. To achieve this, some measures which come to mind are the selection of right species to suit planting sites, the creation of seed-stands, selection of seed trees and improvement of nursery practices, better plantation techniques, the application of manure and fertilizers and careful tending of young seedlings backed by scientific management practices. For higher productivity, education in forestry should take into account these and other related factors.

A short-term programme which might help immediate higher production at the cost of long term benefits and might affect soil and environment cannot be judged as productive. However, well qualified he may be, the forester alone cannot give the care that forests need. He must have the close cooperation of the administration in general and of the people. Hence, education for forestry must include people's education.

The Science Advisory Committee of the Cabinet is also looking into such matters. Careful selection of human *material is of the utmost importance. We need people who are dedicated and who think of forestry not merely as a career.* Of course, those who are working must feel satisfied with their conditions but in this matter I am sorry to say that it is not the Prime Minister who has the last word but the Finance Minister. It is sad that there is such a high rate of depletion of direct recruits and a tendency to treat this service as less than some other. Apart from the fact that every task is important there is something special about trees and closeness to nature. Surely, there do exist young men and women who would respond to the call of this profession, which is interesting as well as emotionally and aesthetically fulfilling ? *We should be able to recruit bright young men and women into forestry. So far very few women have been drawn to it.* Perhaps there is a mistaken belief that it is man's job. But all over the world women are taking on more and more such jobs in all fields of activity. *I wish more women would feel interested in forestry, particularly in social forestry, because it involves direct interaction with village women-folk.*

Education policy should introduce greatest specialization in some areas after good grounding in the multi-disciplinary aspects of forestry. Advanced specialists should also be naturalists who can be competent to advise on subjects, such as, rain, forests, plant genetics, entomology, forest engineering, wet lands, breeding of different species of animals etc. Only too often, specialized work on different species of fauna or flora is left to gifted amateurs or to foresters who retain extra-professional interest or to tenacious pioneers. *With our reserves of talented manpower, we should be in a position to depute specialists to organizations like the International Union of Conservation of Nature rather than to get experts from them.*

Forestry as a whole will gain with more exposure to forestry in universities. Forest colleges should open their doors to students from all disciplines. The problems of our people particularly of tribals living in forests or villages adjacent to sanctuaries should be treated sympathetically in the Forest Research Institute and other forest colleges.

Forests are traditional sources of food, of herbs, of fuel and other essentials of many unsophisticated people who have lived for generations in and off the forests. These people are now bewildered and disturbed by the shrinking of the forest area, the depletion of produce, and numerous restrictions imposed by officials. *The education of the forester and his colleagues in forest sciences should cover the sociology and economics of such communities. Forestry practices should make the lives of forest dwellers, whether human or other species, happier, not worse.* These people should not be driven away from forests. Rather we should be able to *take their help to preserve and work forests scientifically.*

Just as it is realised that exploitation of people must end so must we now recognise that the *exploitation of nature and specially of forests must end. We must evolve programmes by which forests cannot only co-exist but be enlarged side by side with the growth of agriculture and industry and the three together should help our people to raise their standards of living.*

I congratulate the Institute on its Centenary and I am glad to be with you here and to inaugurate the centenary celebrations as well as to release the book that has been brought. To you all who are working in the Institute or studying or are interested in its work, I give my very good wishes for now and for future years.

EDITORIAL

In India pines naturally occurs in the northern Himalayan ranges (*Pinus roxburghii* and *P. wallichiana*) and in eastern regions (*Pinus kesiya*). The absence of pines in the tropical and sub-tropical zones has focused attention on the introduction of pine in this region and the earliest introduction of *P. roxburghii* was made in Cairn Hill at Ootacamund in about 1885. Subsequently, *P. roxburghii* was introduced on an experimental scale in other parts of tropical India *viz.*, Madhya Pradesh, Tamil Nadu, Andhra Pradesh and Orissa. Around 1906 several exotic pines were introduced in south India (2160–2400 m), *P. radiata* was found to be the best among the species tried. Encouraged by the growth of this species about 371 ha had been planted by 1914. Sporadic attempts at introduction of pines continued from time to time, and in 1958 trials of exotic pines were started on a regular systematic basis in different parts of the country.

The National Commission on Agriculture in their report on Production Forestry—Man-made forests recommended that the pulp and paper industry should receive priority in the public sector while the private sector is likely to invest in such industries as saw milling, plywood, particle board and rayon pulp. The vast projected demand for forest products has made it essential that fast-growing species should be used wherever possible, particularly for pulp and paper. Although fast-growing species like *Eucalyptus*, particularly *E. grandis* and *E. tereticornis* are widely planted in India and can be extended in area and genetically improved in quantity and quality of yield by simple programmes of species and provenance trials and mass selection. yet coniferous species specially pines are necessary to produce long fibre that are suitable for a variety of pulp.

The wide natural distribution and genetic variation between and within tropical pine species have aroused considerable interest in the trial of tropical pine with the hope that seed sources may be found that are suitable for a wide range of sites in India with environmental problems including fire, frost, drought etc. The studies on tropical pines were, therefore, taken up and are still in progress at Forest Research Institute, Dehra Dun and trial plantations were raised in a large number of States.

The time is now ripe to pool the available knowledge on tropical pines generated by a number of studies conducted at the Forest Research Institute, Dehra Dun as well as trial plantations carried out by several States and to present the results in two special issues of the *Indian Forester*. Accordingly, the current issue is devoted to the experimental studies on different aspects of tropical pines and the next issue (Feb., 1982) will cover the performance of tropical pine species and their provenances in different States of the Union.

R.N. Kaul

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TROPICAL PINES IN INDIA—AN OVERVIEW*

By

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Introduction

In many of the developing countries the need to develop resources for coniferous wood raw materials is felt keenly. Most of the natural reserves of coniferous forests are with the developed nations. In India there is no more than 6% of the forest area under coniferous woods and yet it is estimated by the National Commission on Agriculture that by 1990, out of 31.1 million m³ of industrial wood needed by then, 7.1 millon m³ will be coniferous (this excludes bamboos). Looking at the list of coniferous trees, the genus *Pinus* stands out as very remarkable one. It has the largest distribution and is found in most divergent climatic conditions. There are about 94 species in this genus and in the Northern Hemisphere, this number is rivalled only by *Quercus*. The range covered by pines is fantastic—from the Arctic circle to tropics, crossing even the Equator in Sumatra. In fact, since their incipience in the Mesozoic era the pines have spread themselves out in almost all of the Northern Hemisphere. If proper migration routes were available there is no reason to believe why pines would have been absent in the upland areas of South India.

Donor regions

Mirov (1967) recognises the following pine regions :

1. Western North America (Canada and U.S.A.).
2. Eastern North America (Canada and U.S.A.).
3. Mexico and mountains of the Central America.
4. The Caribbean area including South Florida and Caribbean Coast of Central America.
5. Northern Eurasia.
6. The Mediterranean area.
7. Eastern Asia upto Indonesia, extending west to Himalayas and including islands of Japan, Formosa, Philippines, Hainan and Sumatra.

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*Paper presented at the 2nd Forestry Conference, 1980, F.R.I., Dehra Dun.

†Presently Director, Forest Training School, Haldwani (U.P.).

The major areas of the pine lie above 22½°N latitude and in most of the areas there is either well distributed or winter type of rainfall. Both these factors viz., latitude and pattern of rainfall exclude the possibility of growing species from the regions 1, 2, 5 and 6 in the tropical India. Many of the species from these zones have been tried in India in the States of Uttar Pradesh, Tamil Nadu, Andhra Pradesh etc., but have never proved worthy of large trials.

From the Himalayan region only *Pinus roxburghii* can be planted South of its natural zone in India and it has not done well in Andhra Pradesh and Tamil Nadu Hills. Except for Supkar in Madhya Pradesh there are no other reports in South where it has done well.

In the South-East Asia region, consisting of North-East India (excluding Himalayan Zone), Burma, Thailand, Vietnam, Laos, Combodia and Philippines, there are two important species: (i) *Pinus kesiya* has a very wide adaptability and is a promising species, (ii) another, *Pinus merkusii* shows fast growth only in the Oceanic climate of Sumatra etc. Inland the growth is slow and there is a long grass stage, adaptability to drought is poor. In fact, according to some authors the inland variety is to be called *Pinus merkusiana* Cooling and Gausen. This species is not a suitable species for major areas under Indian conditions.

Mexico and Central American highlands—The number of species in this zone is very large and the area represents various thermic conditions created by altitude. From amongst a large number of species tested from this area only the following need a mention:

Pinus caribaea var. *hondurensis* inland provenances—high (tropical area).

Pinus oocarpa—high potential but usually the Mexican provenances are poor in form (sub-tropical zone).

Pinus pseudostrobus (including *Pinus doglasiana*, *Pinus montezume*, and *Pinus tenuifolia*)—limited potential (warm temperate zone).

Pinus patula—high potential (warm temperate zone).

Pinus greggii—appears useful (sub-tropical to warm temperate).

Other species have not shown promise.

Caribbean area—*P. caribaea* var. *hondurensis*, var. *bahamensis* and var. *caribaea* are important.

Pinus elliottii var. *elliottii*—useful for moist warm northern sub-tropical areas.

Pinus elliottii var. *densa*—has not been reported doing well as this has a grass stage and may not be well suited for introduction.

Pinus tropicalis and *Pinus occidentalis*—The latter has not shown great promise but the former needs further trials as it may succeed on the exposed ridges within the *Pinus caribaea* sites where *Pinus caribaea* will not grow well.

Climatic requirements

Climatic conditions vary greatly in our country and have their own peculiarities. Many indices have been suggested in this respect. Ghosh (1973), while reviewing the pine introduction in India suggested homoclimal comparisions, Seth (1971) suggested potential productivity, Ghosh (1973) tried to allot P.E. values to various species. But none of these can be used as such to identify the species for a zone.

It will be useful to look at (i) mean annual temperature, (MT), (ii) mean max. temperature of the hottest month (MMHT), (iii) mean min. temperature of the coldest month (MMCT), (iv) total rainfall, (v) 'dryness factor' calculated for the number of months with monthly rainfall R in mm less than 2 T, where T°C = mean monthly temperature. This dryness factor being sum of $\frac{2T-R}{2T}$ for these months. Latitude as such may not be of great importance as it fails to give any significant idea specially with species like *Pinus caribaea*, *Pinus oocarpa*, *Pinus patula*, *Pinus kesiya*, etc. Similarly altitude as such also does not mean much except in terms of temperatures.

Species	MT °C	MMHT °C	MMCT °C	Total R.F. mm	Dryness factors	Remarks
1	2	3	4	5	6	7
P. caribaea var. *hondurensis*	25–27 23–25 21.5–23	31–35 30-32 <03 30–33	18–22 15–18 12–15 12–15	>2000 1500–2000 1000-1500 1300-1800	0–0.5 9.5–1.5 1.5–3.0 1.0–2.0	Better depth of soil and retentivity of moisture will increase the tolerance. Higher the MMHT lesser the tolerance to dryness factor. Frost not liked.
P. caribaea var. *bahamensis*	22–24	32–35 29–30	8–12 8-12	1600-2000 1200-1600	2.0–3.0 0–2.0	More tolerant of extremes and perhaps more suited to northern areas where temps. may go lower, can tolerate couple of days of light frost.
P. caribaea var. *caribaea*	24	32–34	12–18	1500	0–1.0	Based mostly on approx. data for natural zone. But may show intermediate tolerance between two other varieties.

(*Contd.*)

1	2	3	4	5	6	7
P. oocarpa	20–22 17–19	29–31 26–28	13–15 8–14	1200–2000 900-1100	2 3–4	In this zone this is the drought hardy pine. Can tolerate light frost. Though it is not liked.
P. kesiya	16–21	24–30	3–12	1500 or more	1–3	The months in which at least 20–25 mm rainfalls are important; higher this No. higher the dryness factor and higher MMHT tolerated. Lower temp. tolerated better than *P. oocarpa. P. oocarpa* and *P. kesiya* requirements overlap but the latter requires higher R.F. and better distribution for same temperature.
P. elliottii	15–20	22–28	3–10	900–1700	0–2	The distribution rather than total R.F., is more important. It can tolerate low R.F. if it is well distributed. It also seems to like winter temp.
P. patula	13-18	20–25	0–8	1300–2000	0–1.5	Drought tolerance poor. There should be some light frost. Snow not tolerated.

Based on above we may look upon the South African experience of growing pines in colder than tropical zone. The monthly figures for temperature and rainfall are not available but the number of days of rainfall are known. This will help to bring out the importance of some parameters.

Locality	MT °C	MMHT °C	MMCT °C	No. of rainy days	Total R.F.	Pattern	Species performance	Observations
George	16.4	24.5	7.4	131	775	Allthough	el^{++}, ke^{--}, mer^{--}	Low total rainfall.
Grahams Town	16.4	26.8	4.3	90	584	,,	el^{+}	General low rainfall.
Graskop	15.1	22.8	4.2	130	1732	Summer	p^{++}, ke^{++}, el^{++}, o^{--}. mer^{+-},	Low temp. & lower min. temperature.
Harrismith	13.8	25.9	-2.0	67	631	,,	p^{+}, el^{+}, o^{--}	Low temp., total rainfall low.
New Agatha	18.1	25.1	9.9	99	1502	,,	ke^{++}, o^{++}, mer^{++}, p^{++}, el^{++}.	——
Umata	17.6	28.1	2.6	96	648	,,	p^{--}, el^{+}, ke^{+-}, o^{+-}, el^{+-}	Low rainfall, high MMHT.
Port St. John.	20.0	25.6	13.3	114	1148	,,	ke^{++}, o^{++}, mer^{++}, p^{--}, el^{+-}	High MMCT.
Barborton	20.3	28.1	9.8	76	786	,,	ke^{--}, p^{--}, el^{+}, o^{+-}.	Low total rainfall high temp. high MMCT.

p = *P. patula*, ke = *Pinus kesiya*, o = *P. oocarpa*, el = *P. elliottii*, mer = *Pinus merkusii*.
++ = very good, + = reasonable, +− = just average, −− = poor.

Similar calculations are given for certain localities in India.

Locality	MT °C	MMHT °C	MMCT °C	Total R.F.	Dryness factor	Remarks
Koraput	22.7	33.5	9.7	1597	3.5	*caribaea* var. *bahamensis*, *caribaea* var. *hondurensis*, o and ke indicated.
Belgam	23.5	34.2	14.3	1294	3.8	Marginal for *caribaea* as dryness factor is high with only 1294 mm rainfall.
Dehra Dun	22.6	35.6	6.7	2160	2.32	*caribaea*, ke, el, indicated. Growth will be average for o, and p will face problems of high temperature.
Ranikhet	15.6	25.6	5.6	1300	1.0	p, el suitable, ke and o average.
Shillong	16.5	24.1	3.8	2150	1.0	p, el, ke will be suitable, o av.
Kodaikanal	14.0	20.2	8.1	1680	0	p suitable, el, ke will be average not very suitable for o, *caribaea*.
Ooty	14.2	21.9	6.6	1303	0.6	As above.
Imphal	20.3	28.7	2.8	1474	1.0	el, ke could be suitable, p can be tried also MMCT not in favour of o but can be tried.
Jalpaigudi	23.9	31.9	10.6	3267	3.2	*caribaea* indicated, o may be tried.
Chaibasa	26.1	40.0	10.9	1312	3.2	*caribaea* only can be experimented but not likely to succeed.
Jagdalpur	24.6	38.6	9.8	1607	3.3	*Caribaea* only suitable on good soils. May experiment with.
Amarkantak	20.5	36.6	2.0	1693	4.0	o, ke, *caribaea* can come on good soils, ke may be better choice.

Position and potential

The various States who had been attempting introduction on a scale worth mentioning are: Tamil Nadu, Andhra Pradesh, Uttar Pradesh, Madhya Pradesh, Orissa and West Bengal. Data for the last names are not available. It is estimated that by now following is the position of trials and availability of the potential areas in these States.

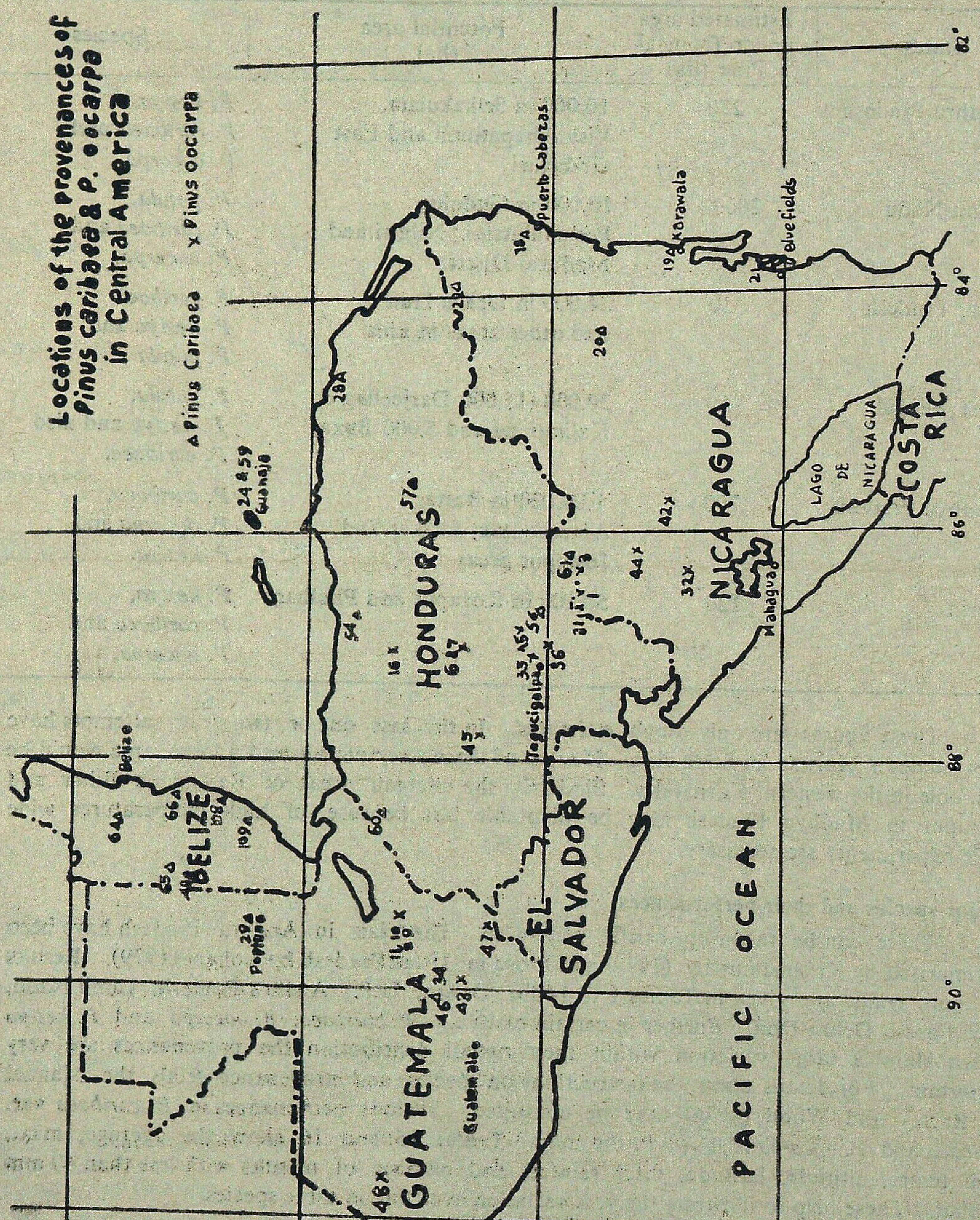
States	Estimated area under Tropical Pine (ha)	Potential area (ha)	Species
Andhra Pradesh	270	10.000 in Srikakulam, Vishakhapatnum and East Godavari	*P. kesiya*, *P. caribaea* and *P. oocarpa*.
Tamil Nadu	2000	10,000 in Gudalur, Perumalmalai ; Nilgiri and Madurai Distts.	*P. patula*, *P. caribaea* and *P. oocarpa*.
Uttar Pradesh	50	24,000 in Dehra Dun and other areas in hills	*P. caribaea*, *P. kesiya* and *P. patula*
West Bengal	50	20,000 (15,000 Darjeeling & Kalimpong and 5,000 Buxa)	*P. patula*, *P. kesiya* and also *P. caribaea*.
Madhya Pradesh	700	1,00,000 in Bastar, Amarkantak, Supkar and Joshipur areas	*P. caribaea*, *P. oocarpa* and *P. kesiya*.
Orissa	120	50,000 in Koraput and Phulbani	*P. kesiya*, *P. caribaea* and *P. oocarpa*.

These figures are only rough estimates. In the last one or two years attempts have been made in Karnataka State also. If some of these attempts succeed a large area would be available in the western Karnataka. Similarly the plateau areas of Ranchi in Bihar and Joshipur in Madhya Pradesh may be plantable but because of high temperatures wide scale experiments are necessary.

Major species and their performances

These can be taken up briefly zone-wise. The trials in Andhra Pradesh have been summarised by Krishnamurthy (1979) and those in Uttar Pradesh by Lohani (1979). Results of some trials are given in Tables 1 to 14 for Orissa, U.P., Andhra Pradesh, Tamil Nadu, New Forest, Dehra Dun. Further in certain cases e.g. *P. caribaea, P. oocarpa* and *P. kesiya* which show a large variation within their natual distribution the provenances are very important. For details about the instructions on species and provenance trials the Manual by Burley and Wood (1976) may be consulted. Various provenances in *P. caribaea* var. *caribaea* and *P. oocarpa* is shown in the map. Tables 15 and 16 show the average, max., min. temp., altitude, latitude, total rainfall and number of months with less than 60 mm rainfall. These help to illustrate the vast variation available in these species.

Pinus caribaea has three varieties viz. *hondurensis*, *bahamensis* and *caribaea*. The last two varieties show comparatively lesser variation within the zone of distribution but the *hondurensis* variety offers maximum variation. The variety *caribaea* is slower grown than



Locations of the provenances of *Pinus caribaea* & *P. oocarpa* in Central America

△ Pinus Caribaea
x Pinus oocarpa
BELIZE
GUATEMALA
HONDURAS
EL SALVADOR
NICARAGUA
COSTA RICA
LAGO DE NICARAGUA
PACIFIC OCEAN
Belize
Poptun
Guatemala
Tegucigalpa
Managua
Bluefields
Puerto Cabezas
Karawala
Guanaja
24 & 59
18°
16°
14°
12°
82°
84°
86°
88°
90°
92°

other two but has a good form. Variety *bahamensis* generally shows high survivals and has an excellent form. It is definitely more resistant to longer drought and to lower min. temperatures. It is indicated for northern latitudes where min. temperatures fall down considerably. The provenance from Andros Island has better performance in general. Though the one from Great Abaco is said to be better in areas where moisture stresses are little.

It must be noted that *Pinus caribaea* has been grown in areas without any moisture stress in most of the countries e.g. Surinam, Malaysia. South Africa, Uganda, Zambia, Fiji, Queensland, etc. The conditions in India are entirely different. The mean max. daily temperatures in these areas, as also in the natural zone of this pine, are usually 31°C or 32°C or so, further, the months in which these temperatures are obtained are not 'dry' months. Hence the results of other countries should be analysed in this context. In these areas *P. caribaea* var. *hondurensis* has always been the superior variety. It is estimated that the planted area under this variety. It is around 2,80,000 ha and the current planting rates may touch 50,000 ha per year (Nickles, 1979). The high rainfall areas along the Atlantic coast have highly acidic sandy soils and uniformly moist and warm climate. Some of the provenances like Alamicamba, Karawala etc. have shown a superior growth in most of the international trials. But there are other inland provenances which do experience a wide moisture stress, though the max. temperatures associated with these months are not high. Some of these should hold a better chance in Indian conditions than the coastal provenances. The results of provenance trials in Koraput and at New Forest are given in the Tables 2–5. It can be seen that provenances from Santa Clara, Loslimones are better than those from coast. Unfortunately, Mountain Pine Ridge provenance is not represented in these but it is felt that this along with Poptun should prove very useful.

Pinus caribaea var. *bahamensis* has established its superiority or equality to var. *hondurensis* in areas like Araku and at Dehra Dun. The seed of this variety is difficult to get.

Thus, *Pinus caribaea* moist provenances like Karawala, Pinar, Brus, Alamicamba, etc. are indicated for coastal highland of Karnataka (Agumbe, Makut etc.) and these are worth trying in Kerala also and so also in parts of West Bengal. In areas of Uttar Pradesh, *Pinus caribaea* var. *bahamensis* from Andros Islands and var. *hondurensis* from Poptun are indicated. In the areas of Koraput, Daringbadi, Araku etc. the Mountain Pine Ridge, Santa Clara, Limones and var. *bahamensis* are indicated. In the hills of Thirumala and adjacent hill systems provenances from Santa Clara, Limones may be well suited.

Pinus oocarpa: This has a large variation. It is not found along the coast and is found above the Caribbean zone. The southernmost distribution is in Nicaragua nearly 13°N latitude and the Northernmost Provenances come from Hidalgo in Mexico 21°45′N latitude. The Mexican provenances do not have good form (except Jitotil) and some of the well known provenances are listed in Table 16. The species does not tolerate high temperatures or very low temperatures but has a great drought resistance in this Zone. It should have a good future in areas like Perumalmalai. It could be trusted even in Bangalore plateau if pH is about 6 or less. It may not have a great future in Northern foot hills because of very low min. temperature. However, this species does require a testing of provenances as the rainfall variation in the natural zone is 800 mm (Chaucus, Guatemala)—2000 mm (Mt. Pine Ridge Belize). The mean yearly temp. varies from 16.9°C (Malacatancite, Guatemala)—24.5°C

(Conacasta, Guatemala). A detailed description has been broughtout by Greaves (1979). and Kemp (1977) have reported that in most of the trials, provenances K_1, K_{42}, K_{44} and K_{49} always occupy the top positions. It may be noted, these are all higher rainfall provenances growing in best conditions. However, attention has been focussed on the provenances K_7, K_{35}, K_{36} from Honduras and K_{10}, K_{11} and K_{34} from Guatemala. These along with Mexican EM70 (Jitotil) may be highly valuable in areas which are not optimum.

Confusion has arisen about the variety *ochoterenai*, this was first described in 1940 following studies of trees in Chiapas Maxico which were distinctly superior to typical *oocarpa* trees in form and growth. Styles (1976) has studied this question and concluded that trees in Chiapas should be called *P. patula* var. *longipedunculate* Loock ex-Martinez. This appears that this should apply to trees in Chiapas only and the term var. *ochoterenai* should not be used.

Pinus oocarpa has shown good growth in upland areas of South e.g. Koraput, Araku, Gudalur, etc. where it may equal the growth of *P. caribaea.* In Dehra Dun it does not show so good a growth. The reason can be (i) lower min. temperature and (ii) higher pH, even in nursery this species appear to be more intolerant of high pH. Certain provenances from Honduras and Guatemala have been obtained, those do not exactly conform to the locations from which Kemp made his collection, but many of these are from similar locations. The seeds have been distributed. However, this species in highly liable to wind throw and is not suitable in areas prone to high velocity winds.

Pinus kesiya: This species did not get as much recognition as *Pinus caribcea* or *Pinus oocarpa* but certainly it is extremely important for areas with good rainfall and those having rather low temperatures in winter. The results of higher region in Eastern Ghats show that this species holds a very great promise in this zone (see the results of trials of Orissa, New Forest in the appendices). Though the form of the commercial seed obtained from Meghalaya is very poor (perhaps the result of native selection) yet at Araku and also at Kalinga, Darigabadi, etc. there are a number of trees which show extremely good form Hence there is a strong case for converting these trials to stands of good trees by removing all the poor form trees and by giving space to good ones. Further there are bound to be some good stands in Jaintia hill and Manipur. Seed from some of these stands should be tried and the stands should be converted to seed stands.

Some of the provenance trials show that growth of some of the provenances from Philippines or Vietnam and the form will be superior. This calls for getting more seed from these countries.

Pinus kesiya has shown good growth in Uttar Pradesh; (Kalika—though the rainfall is not very high there) and in Amarkantak, Madhya Pradesh; Eastern Ghats as mentioned above; Dehra Dun; etc. It is an obvious choice for areas in North-East also. In many of these areas it is as good as *Pinus caribaea. Pinus kesiya* should show better tolerance than *P. oocarpa* to occassional higher and general lower temperatures provided the rainfall is high and well distributed. It is not well suited for medium hills of south where the rainfall is around 1000–1100 mm.

Pinus patula: This warm temperate zone pine occupies the same important position as *Pinus caribaea* does for the tropical zone. Its fast growth has made it very popular in the hilly areas of tropics. It is being extensively planted in Tamil Nadu in the Nilgiris and Palni Hills. It has established its position in afforestation of the degraded oak forests in the middle Himalayan zone in U.P. Again in the hills of West Bengal it is a potential species and may find an important place in the hills of North East. In all these places it has been able to grow about 1 m or more per year. Some of its performances are given below:

	Age	Av. ht. (m)	Av. diam. (cm)	
U.P. Kalika Centre (Alt. 1750 m, rainfall 1300 mm)	10	14.6	16.6	
	9	10.9	15.8	Compared to 6.1 m height of *P. roxburghii* in 10 years.
	7.5	5.3	—	
	6	7.4	7.9	
Sakhidhang (Alt. 1300 m, rainfall 2000 mm)	7.5	9.0	9.0	
	6.5	5.1	6.9	
Dhunaghat (U.P.) (Alt. 1800 m, rainfall 1,000 mm)	9.5	7.5	10.9	
	7.5	7.4	8.9	
	8.5	7.7	9.0	

Tamil Nadu

Age	*S%*	*Av. ht. (m)*	*Av. diam. (cm)*
Kodaikanal			
12	92	14.0	18.4
11	90	14.6	17.7
8	90	11.5	8.8
Upper Bhawani			
8	98	9.5	5.9
6	75	6.4	4.2
Nilgiris			
5	83	4.7	3.3
11	86	11.1	14.2
9	87	12.0	13.1
8	79	5.8	8.5
Cherambady			
7	58	2.8	

West Bengal

Locality	*Age (years)*	*Av. ht. (m)*
Rhimbick	10	8.6
,,	17	11.3
Raman 3	23	17.5
,,	11	10.9
Raman 4	21	18.5
,,	13	14.8
Lava 2	7	6.3
	6	5.2
Batashi 4	6	3.2
Gaddikhana	7	7.1

This species does not prefer high temperature and although the initial growth in places like New Forest may be fast the tree becomes soon flat topped and starts looking ungainly. It is suspected that it is more susceptible to *Diplodea* attack in warmer areas. The difference of growth in South and North is explained by a lower mean temperature in hills of North Bengal (MAT of Darjeeling is 11–12°C) and the fluctuations being higher in temperature than in Kodaikanal.

Pinus patula has a comparatively small distribution in Mexico and this species is fairly uniform. As such, there are no known areas in Mexico with associated characters. However, this is a very widely planted species and seeds from Kenya, Malawi, South Africa, Kodaikanal (India), etc. were tried at certain places considering these as 'Provenances'. The details can be seen in Tables 6–10 for growth data in New Forest and Kalika and Amkharak, (both Uttar Pradesh). The difference is not much. The small difference, if at all, is due to the quality of trees from which the seed is collected.

Pinus greggii : This species is very much related to *Pinus patula* occupying the same zone in Hidalgo in Mexico as that of *Pinus patula*, but also occurring as disjunct in around 25°N latitude and 108°W longitude. This species has an edge over *Pinus patula* in Uttar Pradesh trials in hill zone specially in the outer or start of middle Himalayas but not in the middle Himalayas. At Dehra Dun it has shown fast growth and is the leading species in 1974 trials but it appears that it is not maintaining the same rate of growth and may be overtaken by *P. caribaea*. Similar early fast growth is shown by this species in Orissa hills. The form is generally disappointing and the trees show a wavy growth of stem. At times the top starts twisting and growing out of the vertical. The performance of this species has to be kept under watch. At present it can be tried along with *Pinus patula*. Since *Pinus patula* has the highest potential in Kodaikanal and Ooty this may be tried there. The seed is, however, a problem.

Pinus elliottii : The species, obviously, has a potential in Northern areas only. It appears to thrive better when there is a marked difference in the winter temperatutres. Thus its rate of growth lags behind that of *Pinus patula* quite considerably in Tamil Nadu but the difference in growth is less in places like Dehra Dun and Ranikhet (Kalika). Its high resin yield and higher density should make it a quite suitable species in Northeast and North only. Incidentally this can stand clayey soils better than other pines, but no efforts should be wasted in trying this species in the Dome Areas or South.

Seed problems and seed setting

The cost of seeds of *Pinus caribaea* in particular and other pines in general has gone up very considerably. There are only a few sources and the current prices are in the range of 155–160 $ per kg. The procedures are long and difficult because there does not seem to be a separate set of rules for perishable commodities like seed. Approximately equal amount has to be paid on costoms, clearance agent charges etc. There are no direct flights and even an air letter takes 3–5 weeks to reach the destination. Because of change of flights either some parcels are left out or the documents are incomplete with the results that months elapse between despatch and actual delivery of seeds. There is also a suspicion that due to increase in moisture content the fumigation treatment may lead to depression of germination. Further, the Government or Corporations want payment in advance. Seeds received by post again pose a serious problem because there is no quarantine inspection facility at the foreign post office. On the other hand one cannot go for a large quantity of seed from any source specially from countries who have seed from their own plantations and the plantations have been raised in very different climate.

So far there has been no seed setting in *Pinus caribaea* except for a few small cones observed in Madredumilli, Andhra Pradesh. No seeds are found—actually no mature cones observed in New Forest, even though some of the trees are 16 years old and many 10 years old. The low temperatures in winter are perhaps the main cause of this. Similarly no cones have been observed in *Pinus oocarpa*. *Pinus patula* on the other hand does not produce fertile seed in Dehra Dun but in Ranikhet or in Kodaikanal the seed setting is good, specially at Kodaikanal which has more uniform climate. Moderately fertile seeds are observed in *Pinus elliottii*. Cones have also been observed in *Pinus greggii* in Ranikhet.

Future priorities: The priorities are obviously on the following lines:

(a) Strengthening the organisation on Pine Introduction and Research.

(b) Elemination of hurdles in fast procurement of seed in a safe condition.

(c) (i) Determination of best sources (Provenance trials),
 (ii) Establishment of conservation stands in areas where seed setting is indicated.

(d) Creation of seed stands and selecting plus trees and provision of somewhat improved seeds and establish seed orchards in various localities suitable for seed production.

(e) Progeny testing in different possible environments and culling in orchards accordingly.

(f) Seed from seed orchards.

(g) Controlled crossing.

These points are quite obvious and need no elaboration at this stage.

However, warning must be sounded against expecting much from selections made in other countries. As an example the growth of *Pinus caribaea* var. *hondurensis* raised from seed from natural stands (please see 1974 provenance trials at New Forest, Table 5) and from selected trees from Queensland stands (1975 trials, New Forest, Table 4) can be compared. Not only the height growth is less, the survivals are also less.

Table 1

Growth data of important places

Orissa State

Species	Kalinga 710 m				Pottangi & Maliput 930 m				Daringbadi 945 m				Koraput 910 m			
	Age	S%	Av. Ht.	Av. Diam.	Age	S%	Av. Ht.	Av. Diam.	Age	S%	Av. Ht.	Av. Diam.	Age	S%	Av. Ht.	Av. Diam.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
P. caribaea var. *hondurensis*	15½	59	16.0	17.4	4½	100	8.0	—	4½	100	4.0	—	4½	89	3.7	—
	15½	85	17.4	22.1					4½	99	2.8	—	3½	76	2.4	—
	4½	40	3.1	—									3½*	64–88	1.85–2.6	—
													4½	56	2.6	4.4
P. caribaea var. *bahamensis*	9½	95	7.2	8.4	8½	88	8.0	8.6	9½	92	8.2	7.8	9½	60	7.1	14.6
	7½	81	7.5	8.2	8½	72	10.7	13.0	8½	70	9.1	8.2	5½	89	4.9	6.8
	4½	76	3.9	—	4½	80	3.0	—	7½	100	10.1	9.2	8½	63	10.8	16.9
	4½	77	4.2	—					4½	97	2.8	—	5½	80	2.75	3.2
	4½	81	4.8	—					4½	14–96	2.5–3.9	—	5½	76	3.7	5.4
										different plots			5½	79	3.3	4.4
									3½	73	3.7	—	5½	43	2.4	3.6
													5½	38	2.1	2.5
													3½	76	1.9	—
													3½	72	1.9	—
P. caribaea var. *caribaea*	15½	48	14.2	17.3					3½	91	1.0					
P. kesiya	18½	67	16.5	21.8L	11½	64	9.6	15.6L	11½	62	8.5	6.2L	9½	74	7.5	15.8L
	8½	74	7.1	14.1L	8½	67	7.7	12.4L	10½	92	10.2	8.5L	8⅓	94	8.7	16.9L
	4½	6-98	2.6–5.2*		8½	87	9.4	12.0L	8½	98	8.5	7.2L	½	21	3.3	3.6L
	4½	33	3.9	— L	4½	59	4.7	— E	5½	79	4.9	4.5L	½	88	5.2	10.4L
	7½	66	5.9	10.1L					4½	81-97	3.7-4.6E	—	6½	48	5.7	14.2L
									3½	91	2.1	—L	5½	39	3.9	8.1L
									3½	82	3.8	—L	5½	28	4.1	5.2L
													5½	46	4.4	7.2E
													5½	12	2.8	5.0L
													5½	13	3.2	5.2E
													3½	59–49	2.2–1.4	—E
													5½	45	5.2	7.2L*
													5½	54-79	4.1–4.8	5.7-8.1E*
													4½	63	2.9	7.0L
													4½	72	3.3	7.0E
													4½	82	2.9	7.8L

Table 1 (*Contd.*)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	Gudadia–760 m															
P. kesiya	13	24	13.4	19.0L												
	12	19	13.1	16.6L												
	11	33	10.1	15.2L												
P. oocarpa	4½	38	2.3	—	3½	100	4.9	—	4½	86	3.8	—	5½	52	3.5	4.8
	3½	46	2.0	—					4½	79	3.4	—	5½	17	3.3	2.8
									3½	79	3.5	—	3½	76	2.4	—
									3½	89	2.1	—	3½	69	2.3	—
													5½	28	3.5	3.9
													4½	72	2.3	5.6
P. greggii	2½	81	1.9	—	3½	95	4.2	—					3½	71	3.0	—
P. patula	10½	73	4.8	3.4	8½	76	11.7	12.6	6½	73	4.8	3.4	5½	15	3.3	4.1
	6½	23	5.0	5.4	6½	95	10.5	14.0	4½	95	4.0	—	5½	7	2.2	2.6
	4½	42	3.7		4½	76	3.8	—	4½	79	3.3	—	5½	54	4.4	5.4
	3½	26	2.1						3½	51	3.5		4½	72	2.2	4.6
	3½	94	2.1						3½	62	1.8					
P. elliottii					4½	100	3.4	—					5½	14	2.0	2.2
													5½	6	1.9	2.7
P. taeda	4½	20	1.7	—					4½	84	1.6	—	5½	36	1.6	1.9
	2½	71	0.9						3½	77	3.5	—	5½	16	1.4	1.9
									3½	38	2.2					
P. roxburghii	14½	79	4.5	9.8					4½	94	0.9	—	5½	57	0.9	2.6

* Provenance Trials. L=Indian Origin-Meghalaya. E=Exotic.

S% = Survival percent; Av. Ht. = Average height and Av. Diam. = Average diameter.

Note : Young trails not mentioned.

Table 2

Provenance trials of Pinus cribaea

Koraput centre –Age 3½ year

Variety	Provenance		S%	Max. Ht. (m)	Min. Ht. (m)	Av. Ht. (m)
Hondurensis	Alamicamba	22/70	84	3.3	1.3	2.3
	Riococo	24/70	86	3.3	1.7	2.3
	Guanoja	28/70	72	3.3	1.6	2.4
	Loslimones	36/71	88	3.5	1.8	2.6
	Brus	38/71	7	3.4	2.0	2.5
	Santa Clara	45/71	72	3.5	1.9	2.6
	Santos	43/71	80	3.0	1.4	2.1
	Nicaragua	—	49	1.9	1.0	1.2
	Poptun	—	64	2.6	1.4	1.8
Bahanensis.	Andros	69/7296	76	2.7	1.3	1.9

Table 3

Provenance trials of Pinus kesiya.

I—Koraput—Age=5½ yrs., II—Daringbadi—Age=4½ yrs., III—Kalinga—Age=4½ yrs.

	S%			Max. Ht.			Min. Ht.			Av. Ht.			Av. Diam.		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
Meghalaya	4.6	—	—	7.3	—	—	2.3	—	—	5.2	—	—	7.3	—	—
Philippines 35/S (9258)	57	90	50	7.7	6.5	6.0	2.8	1.6	2.6	4.6	4.1	4.8	6.3	—	—
Thailand 7/S/66 (593)															
Bow Luong	54	—	20	6.8	—	2.8	1.9	—	2.1	4.7	—	2.6	6.0	—	—
South Vietnam 8/S66/ (593)															
A	57	—	34	7.2	—	6.8	2.2	—	3.8	4.2	—	5.2	7.3	—	—
B	—	—	33	—	—	5.2	—	—	3.0	—	—	4.3	—	—	—
Philippines 34/S (9256)	69	88	69	7.0	5.8	6.5	3.0	2.4	3.7	4.4	4.1	4.9	7.5	—	—
Philippines 39/S (9266)	65	—	98	7.2	—	6.3	1.0	—	1.6	4.8	—	4.2	8.1	—	—
Philippines 38/S (9263)	57	97	85	7.5	6.1	6.8	2.0	3.0	2.3	4.4	4.5	4.8	5.7	—	—
Philippines 36/S (9261)	66	—	—	7.0	—	—	1.0	—	—	4.1	—	—	7.1	—	—
Zambia 42/S (9533)	68	81	58	7.0	5.6	6.8	2.0	2.8	2.3	4.4	4.2	4.9	6.9	—	—
Philippines 41/S (9271)	68	—	6	7.0	—	2.1	2.0	—	2.1	4.8	—	2.1	6.8	—	—
Philippines 33/S (9254)	74	89	—	7.0	5.0	—	2.0	2.2	—	4.5	3.7	—	6.4	—	—
Thailand 6/S/66 (593)	79	—	—	7.3	—	—	2.0	—	—	4.6	—	—	7.4	—	—
II—3½ Years Trial II (Part)															
Thailand Chengmai Hod	59	—	—	2.9	—	—	1.5	—	—	2.1					
Thailand Chengmai Doi Hum	49			2.7			1.4			2.2					
Thailand Hod Mae Rid	49			2.6			1.3			1.4					
India Meghalaya	12			2.0			1.0			1.5					
Compare															
Pinus oocarpa															
30/70 Guatemala	76			3.7			1.0			2.4					
FRI—106 Guatemala	69			3.3			1.6			2.3					

Table 4

Some growth data for New Forest

Year of trial	Age at measurement	Species and origin	S%	Av. Ht. (m)	Av. Diam. (cm)
1963	15	*P. patula*, Via. Belize	100	15.3	24 6
1963	15	*P. caribaea* (Mt. Ridge) Via. Belize	42	19.3	32.7
1963	15	*P. pseudostrobus*	42	13.0	22.0
1963	15	*P. kesiya*, Meghalaya	71	14.4	24.5
1963	15	*P. massoniana*, China	80	14.0	24.0
1963	15	*P. elliottii*, Florida	75	17.6	23.8
1963	15	*P. douglasiana*, Via. Belize	12	15.0	25.0
1963	15	*P. cubensis*, Cuba	75	15.7	22.0
1966	12	*P. kesiya*, Philippines	44	15.2	21.2
1966	12	*P. elliottii*, Australia	70	13.6	19.0
1966	12	*P. taeda*, U.S.A.	85	10.6	18.0
1960	10	*P. patula*, Kenya	65	11.0	12.9
1960	10	*P. oocarpa*, Costa Rica	19	12.1	13.4
1960	10	*P. caribaea* var. *bahamensis*, Andros Island	93	13.9	16.6
1973	6	*P. patula*, Malawi	34	6.1	
1973	6	*P. patula*, Australia	27	5.8	
1973	6	*P. patula*, New Zealand	15	6.0	
1973	6	*P. patula*, South Africa	27	5.8	
1973	6	*P. patula*, Kenya	31	6.2	
1973	6	*P. roxburghii*, Dehra Dun	17	5.0	
1975	4	*P. caribaea* var. *hondurensis* Crop trees expt. 460R, R611 & R915, Beerwah, Australia.	43	2.8	
1975	4	*P. caribaea* var. *hondurensis* High pruned select trees R611 Beerwah, Australia.	26	2.9	
1975	4	*P. caribaea*, var. *hondurensis* Plus trees expt. 814 R20, Maryvale, Australia.	27	3.3	
1975	4	*P. caribaea*, var. *hondurensis* High pruned selects R461, Kennedy Atherlton Distt.	27	3.1	
1975	4	*P. caribaea*, var. *hondurensis* R/123/R, Australia.	20	2.5	
1975	4	*P. caribaea* var. *hondurensis* Plus trees expt. 171/R20, Maryvale, Australia	33	3.1	
1975	4	*P. caribaea*, var. *hondurensis* High pruned selects R658, Cathu, Australia.	50	2.9	
1975	4	*P. caribaea*, var. *hondurensis* Crop trees expt. 406, Atherton Distt., Australia.	48	2.8	
1975	4	*P. caribaea* var. *hondurensis* Plus trees expt. 88BR, Maryvale, Australia.	25	2.9	
1975	4	*P. caribaea* var. *hondurensis* Grafted plots expt. 23 Carawatha Logging area R658, Cathu, Mackay Distt., Australia	46	3.2	

Table 5

Vanamahotsava (1974) trial, Forest Research Institute, Dehra Dun

Pinus caribaea Provenance Trials Age = 5½ Yrs.

Treat. No.	Species and Origin	Av. ht. (m)	Av. diam (cm)	Survival (%)
1.	*Pinus caribaea* var. *hondurensis* (Guatemala)	6.35	9.6	95.8
2.	*P. caribaea* var. *caribaea*, Batey Cuba 23/71	6.29	10.4	54.2
3.	*P. caribaea* var. *hondurensis*, Poptun Guatemala 26/70	6.65	10.7	75.0
4.	*P. caribaea* var. *hondurensis*, Alamicamba Nicaragua	7.39	11.6	79.2
5.	*P. caribaea* var. *hondurensis*, Nicaragua	6.44	10.2	83.3
6.	*P. caribaea* var. *hondurensis*, Guatemala (FRI/105)	7.67	11.8	83.3
7.	*P. caribaea* var. *bahamensis*, Andros Island (7396)	7.23	13.3	91.7
8.	*P. caribaea* var. *hondurensis*, Rio coco, Nicaragua 24/70	6.92	11.5	33.2
9.	*P. caribaea* var. *bahamensis*, Andros Island 69 (7296)	7.11	10.5	91.7
10.	*P. patula*—Malawi	7.09	10.8	83.3
11.	*P. patula*—Malawi. Batch No. 693 Zomba Mountain	7.18	10.3	75.0
12.	*P. patula*, Kenya, select	7.07	11.2	83.3
13.	*P. patula*, New Zealand, R/65/BI	7.02	11.2	70.83
14.	P. *patula*, New Zealand, R/55/B	6.91	10.6	62.5
15.	P. *patula*, South Africa	6.92	10.3	58.3
16.	P. *kesiya*, Thailand (0038)	7.12	13.7	79.2
17.	P. *kesiya*—Meghalaya	6.22	10.6	33.3
18.	P. *roxburghii*, Local (Dehra Dun)	4.36	8.4	87.5
19.	P. *roxburghii*, Majra Range, Nahan Div. (H.P.)	3.70	6.8	100.0
20.	P. *roxburghii*, Parbati Valley, Kulu Div. (H.P.)	3.34	6.9	95.8
21.	P. *greggii*—Mexico Lot No. 358	7.80	13.3	83.8
22.	P. *pseudostrobus*, Guatemala	5.24	9.2	91.7
23.	P. *leiophylla*—Thalmahaleo, Amecameca Mexico	5.72	10.9	83.8
24.	P. *glabra*, U.S.A.	5.70	7.4	83.8

Table 6

Provenance trials, New Forest, Dehra Dun (U.P.).

Pinus kesiya

Age = 6 Yrs.

9548 (Ex-Zambia)	55	6.4	8.8
9263 (Philippines) 16° 19′ Lat.	48	6.1	9.4
9254 (Philippines) 18° 15′ Lat.	26	5.8	8.2
9268 (Philippines) 16° 01′ Lat.	8	5.8	6.8
9261 (Philippines) 16° 51′ Lat.	25	5.8	8.8
9256 (Philippines) 17° 33′ Lat.	30	5.8	8.8
9271 (Philippines) 16° 30′ Lat.	23	5.9	8.8
9258 (Philippines) 16° 54′ Lat.	61	6.4	8.9
Thailand	41	5.8	8.6
9533 (Ex-Zambia) Vietnam	43	6.0	8.4
Check *Pinus caribaea*—Andros Islands	80	8.5	12.4

Table 7

Summary of trials in Uttar Pradesh, Hill Zone

Kalika Centre	Av. ht. (m)	Av. diam. (cm)	Maheshkhan Centre	Av. ht. (m)	Av. diam. (cm)
Age 15½ years :			Age 16½ years :		
P. taeda	15.4	27.1	*P. patula*	17.1	26.9
P. pseudostrobus	14.6	21.3	*P. montezumae*	14.1	25.8
P. tenuifolia	14.6	14.7	*P. pseudostrobus*	14.7	28.3
P. patula	12.5	16.9–12.5	*P. taeda*	7.6	11.6
P. michoachana	13.6	16.9	*P. elliottii*	7.3	10.9
P. caribaea	10.0	14.0			
P. douglasiana	8.8	15.8			

Pinus tenuifolia shows steep rise in height in last few years and may come up in 1st place.

	Age yrs.	Av. ht. (m)	Av. diam. (cm)	Sukhidhang			Lohaghat Centre		
				Age (yrs.)	Av. ht. (m)	Av.diam. (cm)	Age (yrs.)	Av.ht. (m)	Av. diam. (cm)
P. patula	10.0	14.6	16.6	7.5	9.0	9.0	9.5	7.5	10.9
	8.0	6.3	7.2	6.5	6.5	7.3	7.75	7.4	—
	5.5	5.9	—	6.5	5.1	6.9	8.5	7.7	9.0
	6.0	7.4	7.9	5.0	3.9	—	4.5	2.6	—
	4.5	2.9	—	3.5	2.3	—	7.0	7.0	—
	5.0	4.9	—	—	—	—	6.0	4.9	—
	6.5	4.3	—						
	10.0	4.3	—						
	10.0	4.6	16.6						
P. elliottii	14.5	9.9	20.2	6.5	3.4	5.1			
	13.0	9.5	13.9						
	11.0	9.3	14.5						
	8.0	9.5	13.9						
	9.0	10.2	15.7						
P. greggii	9.0	9.7	14.4	7.5	10.6	12.4	9.5	7.6	11.2
	8.0	6.2	—	6.5	7.5	11.6	7.75	6.3	—
	7.5	7.2	—	3.5	2.5	—	8.5	7.3	10.4
	8.0	5.3					4.5	4.1	—
	4.5	3.9					7.0	5.8	—
	6.5	5.1					6.0	4.2	—
P. taeda	12.0	10.9	18.7						
	8.0	11.1	14.7						
	4.5	3.3	—						
	6.5	4.3	—						
	9.0	8.4	15.0						
P. pseudostrobus	8.0	6.5	—	3.5	1.78	—	9.5	6.1	9.3
	3.5	2.2	—						
	6.5	4.0	—						
P. oocarpa	12.0	8.4	11.5	6.5	3.1	5.1			
	12.0	8.6	11.1	5.0	3.3				

Note: Kalika—Alt.—1750–1980 m, rainfall 1300 mm, soils micaceous sandy loam.
Sukhidhang—Alt.-1100–1300 m, rainfall 2000 mm, soils clayey loam deep, pH—7.
Lohaghat/Dhunaghat—Alt. 1700–1800 m, rainfall 2000 mm, soils clayey loam deep pH-6.7

Table 8

Plains Region

Lalkua—Average max. temperature of hottest months about 38°C, Rainfall=1800 mm. Forests occasional in winter—soil clayey loam.

Age—8 years	S%	Av. ht. (m)	Av. diam. (cm)
P. kesiya	40.7	4.0	8.6
P. caribaea var. *bahamensis*	25.9	10.4	15.3
P. elliottii	40.7	9.4	14.5
Age—4 years			
P. greggii	19.0	3.1	
P. kesiya	35.0	2.5	
P. caribaea	29.0	4.1	
P. elliottii	15.0	1.2	
Mala—Summers very hot with some *loo*, Rainfall—1200 mm.			
Age—5 years.			
P. caribaea	57.0	4.9	

Table 9

Provenance trials of Pinus caribaea

Age—3 years	S%	Av. ht. (m)
Kalsi origin :		
P. caribaea var. *hondurensis*		
Nicaragua 22/70	22	2.1
Nicaragua 24/70	21	1.8
Guatemala 26/70	15	1.5
Guatemala F.R.I./105	37	2.2
Nicaragua	79	2.1
Guatemala	50	1.9
P. caribaea var. *caribaea* Batey 23/71	13	1.6
P. roxburghii	60	1.1

Table 10

Pinus patula

Amkharak 1100 m, rainfall 2000 mm, age 12½ years

Pinus patula			
South Africa	33	1.1	
Tanzania	45	1.1	(this plot was grazed)
Kenya	18	0.6	
Pinus roxburghii	15	0.6	
Kalika—Age—10 Years			
Pinus patula			
Kenya	45	12.31	
Malawi	47	12.47	
Mexico	60	12.4	
Kalika—Age 5 years			
Pinus patula			
South Africa	80	4.4	
Kenya	83	5.1	
Malawi	85	5.1	
Kodaikanal	72	4.6	
Pinus roxburghii	82	1.1	

Table 11

Summary of growth for Tamil Nadu

Species	Locality	Age	Survival (%)	Av. ht. (m)	Av. diam. (cm)
1	2	3	4	5	6
P. *caribaea*	Kodaikanal	11	96	12.9	12.9
	Kodaikanal	10	76	15.9	15.9
	,,	9	32	9.9	15.6
	,,	2	62	1.0	
	,,	1	97	0.31	
	Topslip	11	67	2.32	
	Ooty	7	38	1.38	
	Ooty	8	49	2.86	
	Cherambady	7	5	1.6	
	,,	8	51	4.1	5.2
P. *elliottii*	Kodaikanal	13	95	13.6	16.8
	,,	12	54	12.0	20.8
	,,	2	63	0.89	
	,,	1	95	0.58	
	Ooty	7	20	5.78	7.4
	Ooty	9	79	6.87	10.7
	Ooty	5	81	2.40	6.5

(*Contd.*)

Table 11 (*Contd.*)

1	2	3	4	5	6
P. greggii	Kodaikanal	2	66	1.70	
	Ooty	10	63	10.75	15.0
P. kesiya	Kodaikanal	11	86	10.75	16.6
	,,	10	40	6.50	8.8
	,,	9	39	9.4	6.7
	Ooty	12	72	11.22	14.7
	Kodaikanal	12	83	11.50	11.7
P. oocarpa	Kodaikanal	4	82	3.3	
	,,	2	82	1.2	
	Ooty	9	46	6 1	8.9
	Ooty	10	50	9.0	10.7
	Cherambady	7	78	1.4	
P. patula	Kodaikanal	12	92	14.00	18.4
	,,	11	90	14.6	17.7
	,,	10	94	13.5	18.5
	,,	9	96	12.8	
	,,	8	99	11.5	8.8
P. patula	Upper Bhavani	9	93	9.0	6.8
	,,	8	98	9.5	5.9
	,,	7	90	7.8	4.5
	,,	6	75	6.4	4.2
	,,	5	65	1.7	
	Parsons Valley	5	83	4.7	3.3
	Ooty	11	86	11.10	14.2
	Ooty	10	98	13.20	13.2
	Ooty	9	87	12.0	13.1
	Ooty	8	79	5.83	8.5
	Cheramabady	7	58	2.80	
P. pseudostrobus	Kodaikanal	12	84	14.50	20.80
	,,	10	90	13.00	17.80
	Top Slip	12	50	8.30	11.6
	Ooty	11	85	9.69	16.3
	Ooty	10	80	10.68	19.2
	Ooty	9	94	11.35	13.9
P. taeda	Kodaikanal	13	97	13.6	20.5
	,,	12	90	12.25	19.8
	,,	10	68	10.5	10.20
	,,	9	52	7.2	12.16
	,,	4	69	2.15	
	Top Slip	12	25	2.4	
	Ooty	10	92	10.95	13.5
	Ooty	9	98	10.0	13.1
	Parsons Valley	5	70	0.98	
	Governor Shola	2	24	0.24	

Table 12

Growth data, Andhra Pradesh

Ref. of species	Species on trial with ranking	For best		Age (yrs.)
		Av. ht. (m)	Av. diam. (cm)	
	Araku			
I=*P. caribaea* var. *hondurensis*	VII	10.0	—	12
	IV, VI, II, IX	13.5	—	10
	I, II, III, VIII, IX	9.9	—	9
	I, II, IX, III, V	6.8		6
II=*P. caribaea* var. *bahamensis*	VI, VIII, IX, V, I, II, VII	3.63	—	3
	II, I, III, IX, V	16.1	—	7
	I, II, (III, IX) V, I, VII	7.6	12.0	7
	II, I, III, V	7.15	9.1	7
III=*P. caribaea* var. *caribaea*	II, VIII, V, I, III, VIII. II	4.2	7.0	6
	VIII, II, (I, VII), III, II	5.7	7.3	6
	II, IX, VII, VIII, III, II, III	4.5	6.2	6
	II, (I, II), III, I	4.1	6.8	6
IV=*P. oocarpa* var. *ochoterenai*	VIII, II, I, II, VII, V, II, VIII, V, I, V, IX	4.9	7.9	6
	(II, IV, VI), (V, VI, II), (I, VII, IX), II, V, V, III	2.1	4.8	3
V=*P. oocarpa*	I, I, I, II, II, III, IX, V	12.9	21.6	8
VI=*P. greggii*	**Maredumilli**			
	II, I	9.5	10.8	8
VII=*P. kesiya* (Indian)	VII, II, IV, VII, II. I, II, III	8.9	7,0	7
	II, I, II, VIII, II, I, VIII, IX, III, VII, V	8.8	11.8	6
VIII=*P. kesiya* (exotic)	II, VIII, X, VIII, I	6.2	6.0	5
	IV, IV, VII, IX, I	3.0	6.7	4
XI=*P. patula*	**Chintapally**			
	VIII, IX, VII, II	6.7	10.8	5
X=*P. tropicalis*	VI, IX, V, VIII (VII, VIII), VIII, II	6.7	8.9	5
	VI, V, I, V, VII, II. V, I	3.1	—	5

Note : Species in parenthesis have similar growth.

Table 13

Provenance trial (Araku, Andhra Pradesh)

Pinus kesiya—Age=4 yrs.

Provenance No.	Survival (%)	Av. ht. (m)	Av. diam. (cm)
9257	83	3.35	6.0
9258	83	3.05	6.0
9261	85	3.0	6.0
9263	89	3.35	6.3
9264	88	3.0	5.9
9272	84	3.26	6.2
9272	86	3.45	6.0
9278			
9268	87	3.0	5.8
9548	87	3.29	6.1
9533	86	3.31	5.9
Pinus tiwanensis	83	3.31	5.9

These are from Philippines; 9533 and 9548 are Ex-Zambian derived from Vietnam and Ex-Zambian derived from Philippines respectively.

Table 14

Abstract of sample plots

Locality and year of planting	Age (yrs.)	No./ha	Av. ht. (m)	Av. diam. (cm)	Volume	Thinning
Species : *Pinus kesiya*						
Baripada, Orissa, Duduruchampa (1938)	33	445	26.5	26.4	82.8 (stem timber)	6.6 (ST),
	40	410		28.9		5.4 (SW)
Koraput, Orissa (1969)	7½	1450	8.1	12.7	71.7 (ob) or 47.1 (ub)	
Koraput, Orissa (1968)	8½	922	8.0	13.9	49.6 (ob) or 36.4 (ub)	
Koraput, Orissa (1970)	6½	690	16.1	10.2	17.1 (ob) or 11.7 (ub)	
Balliguda Afforestation Div., Orissa (1971)	5½	1539	6.4	9.9	39.2 (ob) or 27.4 (ub)	
Balliguda Afforestation Div , Orissa (1968)	8½	1748	10.5	13.1	118.1 (ob) or 83.8 (ub)	
Balliguda Afforestation Div., Orissa (1669)	7½	1583	11.3	13.2	115.0 (ob)	
Balliguda Afforestation Div., Orissa (1968)	10½	1515	11.2	13.5	118.2 (ob) or 87.6 (ub)	
Karanjia Division near Gudgudia (1963)	13½	841	14.0	17.7	132.2 (ob) or 103.4 (ub)	
Philippines Origin :—Kaligad, West Almora, U.P. (1966)	7½	923	5.9	8.5	24.5 (ob)	
	9½	883	8.0	12.2	39.8 (ob)	0.018 (SW)
Species :—*Pinus elliottii*						
Kaligad, West Almora, U.P. (1965)	8½	927	5.4	9.1	15.3 (ob)	
	10½	927	7.1	11.9	34.8 (ob)	
Kaligad, West Almora, U.P. (1966)	7½	556	6.1	8.9	11.2 (ob)	
	9½	556	7.5	11.9	23.8 (ob)	
F.R.I., Dehra Dun (1958)	13½	1195	11.2	16.6	156.8 (ob)	
F.R.I., Dehra Dun (1948)	23½	621	18.0	25.2		
	26½	621	—	27.8		
Species :—*Pinus patula*						
Gagar, Nainital, U.P. (1962)	11½	493	12.6	20.6	87.6 (ob)	
Kaligad, West Almora, U.P. (1962)	11⅓	672	10.0	12.1	33.8 (ob)	
	13½	672	11.3	13.9	49.9 (ob)	
F.R.I., Dehra Dun (1963)	8½	738	10.4	15.8	61.0 (ob)	
Species :—*Pinus taeda*						
Kaligad, West Almora, U.P. (1965)	8½	962	6.6	9.3	23.5 (ob)	
	10½	962	8.8	12.1	44.3 (ob)	

Table 15

Seed sources of Pinus caribaea var. *hondurensis*

Stock Provenance No.	Country site	Long. N. Long. W.	Alt. (m)	Rainfall (mm)	Dry months	Deficit months	Mean temp. (°C)	Mean daily max. hottest month (°C)	Mean daily min. coldest month (°C)
20/70 K-18	Nicaragua Kuakuil	14°12′ 83°30′	20	3200	2 D	0	26.5	30.9	21.5
21/70 K-19	Nicaragua Karawala	12°58′ 83°34′	∠10	3900	0 D	0	26.4	30 2	22.8
22/70 K-20	Nicaragua Alamicamba	13°34′ 84°17′	25	2600	1 D	0	27.3	—	—
23/70 K-21	Nicaragua Pinar	12°13′ 83°42′	∠10	4200	0 D	0	26.4	30.2	22.8
24/70 K-22	Nicaragua Rio Coco	14°45′ 83°55′	70	2800	0 D	0	25.8	34.3	19.4
26/70 K-29	Guatemala Poptun	16°21′ 89°25′	500	1700	3 C	2	24.2	30.5	18.0
27/70 K-23	Honduras Rep. Brus	15°45′ 84°40′	∠10	2800	1 D	1	26.5	31.7	21.5
28/70 K-24	Honduras Rep. Guanaja	16°27′ 85°54′	75	2300	0 D	0	27. 1	31.9	22.9
29/70 K-25	Guatemala Poptun	16°21′ 89°25′	500	1700	3 C	2	24.2	30.9	18.0
32/71 K-52	Nicaragua Pinar	12°13′ 82°42′	∠10	4000	0 D	0	26.4	30.2	22.8
33/71 K-53	Nicaragua Karawala	12°50′ 83°34′	∠10	3500	0 D	0	26.4	30.2	22.8
34/71 K-54	Honduras Rep. Briones	15°34′ 86°44′	300	900	5 C	3	24.0	—	—
36/71 K-56	Honduras Rep. Limones	14°03′ 86°42′	700	660	6 A	6	22.2	29.8	15.0
37/71 K-57	Honduras Rep. Culmi	15°06′ 85°37′	550	1325	5 B	4	24.3	—	—
38/71 K-58	Honduras Rep. Brus	15°45′ 84°40′	∠10	2800	1 D	1	26.5	31.7	21.5
39/71 K-59	Honduras Rep. Guanaja	16°28′ 85°54′	75	2300	0 D	0	27.1	31.9	22.9
40/71 K-60	Honduras Rep. Potosi	15°20′ 88°25′	650	1200	4 B	4	23.7	—	—
41/71 K-62	Nicaragua Alamicamba	13°34′ 84°17′	25	2600	1 D	0	27.3	—	—
43/71 K-64	B.R. Honduras Santos	17°34′ 88°30′	30	1800	1 D	1	26.2	—	—
44/71 K-65	B.R. Honduras Nt. Pine Ridge	17°00′ 88°55′	480	1600	3 C	1	21.2	29.0	14.8
45/71 K-61	Nicaragua Santa Clara	13°48′ 86°12′	700	1800	3 C	2	23.4	—	—
46/71	Queensland Australia	Clonal Res							
47/71 K-66	B.R. Honduras Melinda	17°00′ 88°22′	20	2000	1 D	1	26.9	32.3	20.4
		Pinus caribaea var. *bahamensis*							
69/7296	Bahamas	24°30′	∠10	1650	4 C	4	25.4	32.3	17.6
		Pinus caribaea var. *caribaea*							
18/71	Cuba Marabijita	22°50′ 83°50′	80	1600	5 C	—	—	—	—
19/71	Cuba Los Talacios	22°50′ 83°50′	50	1500	5 C	—	—	—	—
20/71	Cuba Las Cabanas (La Guira)	22°50′ 83°50′	160	1600	5 C	—	—	—	—
21/71	Cuba Manuel (La Guira)	22°50′ 83°50′	150	1600	5 C	—	—	—	—
22/71	Cuba Cayo La Mala	22°50′ 83°50′	110	1400	5 C	—	—	—	—
23/71	Cuba Marbagita	22°50′ 83°50′	80	1600	5 C	—	—	—	—
24/71	Cuba	22°50′	300	1600	5 C	—	—	—	—

Note :—In the 6th Col. months ∠60 mm rainfall. The figures A.B.C. etc. denote the severity of the dry season, A is the most severely dry, D is least dry.

Deficit month is one having ∠2T mm rainfall where T°C is mean temperature for a month.

Table 16

Seed sources of Pinus oocarpa

Stock Provenance No.	Country site	Long N. Long W.	Alt. (m)	Rainfall (mm)	Dry months	Deficit months	Mean temp. (°C)	Mean daily max. hottest month (°C)	Mean daily min. coldest month (°C)
1/70 K–1	Nicaragua Camelias	13°46′ 86°18′	900	1500	5 B	4	22.4	—	—
2/70 K–2	Nicaragua Camelias	13°46′	900	1500	5 B	4	22.4	—	—
3/70 K–3	Nicaragua Sullates	13°51′ 86°16′	1050	1845	3 B	2	21.6	—	—
6/70 K–6	Honduras Zapotillo	14°37′ 87°02′	1100	1200	5 B	2	21.8	—	—
7/70 K–7	Honduras Sam Marces	14°36′ 87°00′	1100	1200	5 B	5	21.3	—	—
9/70 K–9	Guatemala Canas	15°10′ 89°25′	1200	1900	6 B	6	21.3	—	—
10/70 K–10	Guatemala Lima	15°11′ 89°21′	1000	1800	6 B	6	22.4	—	—
11/70 K–11	Guatemala Conacaste	15°10′ 89°21′	650	1900	6 B	6	24.6	—	—
14/70 K–14	Honduras Zapotillo	14°37′ 87°02′	1000	1270	5 B	5	21.8	—	—
15/70 K–15	Honduras Maraquito	14°30′ 86°50′	1000	1270	5 B	5	21.8	—	—
16/70 K–16	Honduras Agua Fria	15°16′ 87°06′	1100	1070	5 D	4	21.6	—	—
1/71 K–31	Nicaragua Junquillo	13°42′ 86°35′	1000	900	5–6A	6	21.8	—	—
2/71 K–32	Nicaragua Bonete	12°50′ 86°18′	950	920	6 A	6	21.4	—	—
3/71 K–34	Guatemala Bucaral	15°01′ 90°09′	1100	900	6 A	6	21.6	—	—
4/71 K–35	Honduras Angeles	14°07′ 87°04′	1300	920	6 A	5	20.2	—	—
5/71 K–36	Honduras Zamorano	13°56′ 86°59′	1100	1100	6 A	50.4	20.4	—	—
6/71 K–42	Nicaragua Yucul	12°55′ 85°47′	900	1400	5 B	5	22.4	—	—
8/71 K–43	Guatemala Langunilla	14°42′ 89°57′	1600	950	6 A	6	19.5	—	—
27/71 K–44	Nicaragua Rafael	13°12′ 86°06′	1200	1360	3 B	3	20.8	—	—
7/71 K–45	Honduras Siguatepeque	14°32′ 87°50′	1100	1250	6 B	4	19.9	30.6	10.4
9/71 K–46	Guafemala Chuacus	15°02′ 90°16′	1300	800	6 A	6	22.5	30.6	14.4
9/71 K–48	Guatemala Malacatancito	15°13′ 91°32′	1700	1040	6 A	6	16.9	27.5	8.2
30/71 K–49	Belize Mt. Pine Ridge	17°00′ 88°55′	700	2000	1 C	1	21.2	29.0	14.8
31/71	Mexico Jitotil	17°05′ 92°30′	1600	—	—	—	—	—	—

SUMMARY

Pines are the 'in species' today. The developing countries in the tropics have been raising large scale plantations of pines and this activity is on the increase. *Pinus caribaea* and *Pinus patula* have been planted so extensively that the area under plantations exceeds substantially the area occupied by these species in their natural habitat.

The paper discusses in various considerations like 'Donor Regions', climatic conditions—specially the temperature and rainfall effects which should be taken into account in selecting the suitable species and lists some of these factors for the important species, illustrating the point with examples from local and foreign habitats where pines have been grown.

There is already an estimated 3200 ha of land brought under tropical pines in India. The potential is, however, very large. The potential areas and the species are also listed.

Provenance research is extremely important for species having a large distribution. The various provenances within *Pinus caribaea* and *Pinus oocarpa* are listed and their important features given. The performance of important species like *Pinus caribaea*, *Pinus oocarpa*, *Pinus patula*, *Pinus kesiya*, *Pinus greggii*, and *Pinus elliottii* in various trial centres is discussed. The importance of inland provenances of *Pinus caribaea* in India is brought out by analysis of results of provenance trials. Emphasis has been laid on the introduction of better forms of *Pinus kesiya* from Vietnam and Philippines.

Problems of seed procurement and of seed setting are discussed and the future line of work is indicated.

भारत में उष्णदेशीय चीड़—एक परिदृश्य

लेखक जी० सी० पाण्डे

सारांश

चीड़ आजकल 'स्वीकृत जाति' हैं। उष्ण कटिबंध के विकासमान देश बड़े परिमाण पर चीड़ के रोपवन लगा रहे हैं तथा यह क्रिया निरन्तर बढ़ती जा रही है। *पाइनस कैरिबिया* और *पाइनस पैटुला* इतने अधिक लगाए गए हैं कि इनका रोपवन क्षेत्र प्राकृतिक आवास में इन जातियों द्वारा ग्रहीत किए क्षेत्र से भी बढ़ गया है।

इस अभिपत्र में प्रदाता क्षेत्र, जलवायु दशाएं, विशेषकर तापमान और वर्षा के प्रभाव जैसी विभिन्न बातों पर विचार किया गया है जिन पर उपयुक्त जातियाँ चुनते समय ध्यान दिया जाना चाहिए तथा स्थानीय और विदेशी प्राकृतावासों से, जहाँ इन चीड़ों को उगाया जा रहा है, उदाहरण लेकर बात समझाते हुए इन महत्वपूर्ण जातियों के बारे में इन कारकों की सूची बनाई गई है।

भारत में अबतक अनुमानतः 3200 हेक्टेयर भू क्षेत्र में उष्णदेशीय चीड़ लगाए जा चुके हैं। इनकी संभावना अभी बहुत अधिक है। संभावित क्षेत्रों और जातियों की सूची भी दी गई है।

अधिक विस्तृत क्षेत्र में लगी हुई जातियों के लिए उत्पत्ति स्थान अनुसंधान अत्यधिक महत्व का है। *पाइनस कैरिबिया* और *पाइनस पैटुला* के विभिन्न उत्पत्ति स्थान सूची में दिए गए हैं और उनकी महत्वपूर्ण विशिष्टताएं बताई गई हैं। *पाइनस कैरिबिया, पा० ऊकार्पा, पा० पैटुला, पा० केसिया, पा० ग्रेगिआई* और *पा० इलियटिआई* जैसी महत्वपूर्ण जातियों को विभिन्न परीक्षण क्षेत्रों देखी गई क्रियाशीलता का विवेचन किया गया है। भारत में *पाइनस कैरिबिया* के अन्तर्देशीय उत्पत्ति स्थानों का महत्व उत्पत्ति स्थान परीक्षणों के विश्लेषण द्वारा समझाया गया है। *पाइनस केसिया* के वीयतनामी और फिलीपीनी श्रेष्ठतर रूपों को लगवाने पर जोर दिया गया है।

बीज मंगाने और बीज स्थापन की समस्याओं पर विचार किया गया है तथा आगे के अनुसंधान कार्य की दिशा का संकेत भी दिया गया है।

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PERFORMANCE OF DIFFERENT PROVENANCES OF CHIR PINE IN COMPARISON TO *PINUS CARIBAEA*, *PINUS PATULA* AND *PINUS KESIYA* IN THE SUB-HIMALAYAN ZONE

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Introduction

Chir pine (*Pinus roxburghii*) is one of the most important pines of the Himalayan region, occurring from Baluchistan in the west to Sikkim in the east, through Pakistan, India and Nepal, from an altitude of about 600 m to about 1500 m, under varying climatic, topographic and edaphic conditions. The species even extends upto 2400 m elevation under certain conditions of quartzite formations in the Himalayas. The species yields valuable timber and pulpwood and is the main source of oleoresin which is obtained by tapping of chir trees and is used for production of rosin, turpentine oil, camphor and a host of chemical byproducts. Due to the wide range of occurrence of this species, there is a great variation in its growth, form, resin yield and quality from locality to locality. The species is good seeder and is easy to propagate for artificial plantations. It has been introduced outside its natural habitat with varying success in Punjab, Haryana, Uttar Pradesh and Madhya Pradesh etc. Looking to its wide spectrum variation in growth and yield characters, the chir pine has a great potential for selection and tree improvement for varied uses. It was, therefore, decided to intensify research for evaluation of different provenances of chir pine for their growth etc. The interim results of one of the experiments on provenance trial of chir pine are reported in this paper.

Material and methods

The study was conducted in the Kaulagarh block of the experimental area of the Forest Research Institute, Dehra Dun (India) which is situated between latitude 30°-20′ N and longitude 78°-3′E, at an elevation of about 610 m.

The area receives mean annual rainfall of 2058 mm, about 87% of which is received from mid June to mid September. The mean maximum monthly temperature recorded is 35.6°C (in May-June) and mean minimum temperature is 3.4°C (in January-February), which maximum and minimum daily temperatures are 40°C and (—) 0.3°C, respectively.

The area is almost flat with good surface drainage. Soil is recent deep alluvium situated at the foothills of Himalayas in the Doon valley. The soil texture varies from silty clay loam in the surface layer to silty clay in the deeper layers with the organic carbon from 0.60 to 0.32 per cent, total nitrogen 0.0498 to 0.1498 per cent, water holding capacity 50.33 to 60.89 per cent and pH from 6.0 to 6.5. The experimental area was earlier under a tea garden alongwith miscellaneous tree species grown for cover.

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CORRIGENDUM

Article "Tropical Pines in India—An Overview" by G.C. Pande, *Indian Forester*, January, 1982, Vol. 108, No. 1.

Page 1 (Footnote)	Read 'Institute' instead of 'School'.
Page 2 (Line 22)	Add 'potential' after high.
Page 3 (Table–line 2, Col. 6)	Read '0.5—1.5' instead '9.5—1.5'.
Page 4 Table–Col. 7, under *P. kesiya,* line 6)	Read 'Lower' instead 'higher'.
Page 4 (Table–Col. 7, under *P. elliottii*, last line)	Add 'lower' after 'like'.
Page 6 (Jagdalpur–under Col. Remarks)	Read 'May experiment with o'.
Page 11 (Table)	Read rainfall of Dhunaghat '1500 mm' instead '1000 mm'.
Page 12 (Para 2, line 11)	Read 'Tables 4, 5 and 10' instead 'Tables 6–10'.
Page 20 (Footnote)	Read rainfall '1500 mm' instead '2000 mm'.

Treatments: 15 treatments comprising of twelve provenances of chir pine (*Pinus roxburghii*) and one provenance each of *Pinus caribaea*, *P. patula* and *P. kesiya* were used for this experiment as per details below:

Treatment	Species	Origin	Description of locality
T_1	*Pinus roxburghii*	India	Majra range, Nahan Div., Himachal Pradesh, lat. 30°–40′N, long. 77°–10′E, rainfall 2307 mm.
T_2	,, ,,	,,	Chamba Div., Himachal Pradesh, lat. 32°–35′N, long. 76°–10′E, Bhaloor range.
T_3	,, ,,	,,	Kulu, Himachal Pradesh, lat. 31°–50′N, long. 77°–5′E, alt. 1550 m, annual rainfall 1090 mm.
T_4	,, ,,	,,	Dehra Dun, Uttar Pradesh, lat. 30°–20′N, long. 78°–3′E, alt. 610 m, rainfall 2058 mm, max. temp. 27.8°C, min. Temp. 13.2°C.
T_5	,, ,,	,,	Hamirpur, Himachal Pradesh, lat. 31°–30′N, long. 76°–30′E, alt. 770 m.
T_6	,, ,,	,,	Dalhausie Div., Himachal Pradesh, lat. 32°–35′N long. 76°E, alt. 1350 m to 1500 m, rainfall 2250 mm annually, max. temp. 35°C, min. temp. 18°C.
T_7	,, ,,	,,	Tikri range, Chamba Div., Himachal Pradesh, lat. 32°–38′ N, long. 76°–4′E, alt. 1350 m, annual rainfall 1143 mm, max. temp. 34°C, min. temp. 0.8°C.
T_8	,, ,,	,,	Darkoti range, Chamba Div., Himachal Pradesh.
T_9	,, ,,	,,	Saing range, Saraj Div., Himachal Pradesh, lat. 31°–45′N, long. 77°–20′E, alt. 1500 m.
T_{10}	,, ,,	,,	Parbati Valley, Kulu Div., Himachal Pradesh, lat. 31°–55′N, long, 77°–15′E, alt. 1219 m, rainfall 1147 mm.
T_{11}	,, ,,	,,	Gochar Forest, Bilaspur Div., Himachal Pradesh, lat. 31°–16′N, long. 76°–50′E.
T_{12}	,, ,,	,,	Rajgarh Div., Himachal Pradesh, lat. 30°–40′N, long. 77°–15′E.
T_{13}	*Pinus caribaea*	Cuba	Batey, Cuba, CFI Oxford Seed lot No. 23/71.
T_{14}	*Pinus patula*	New-zealand	Details not known, Newzealand seed lot No. R/65/B.
T_{15}	*Pinus kesiya*	India	Meghalaya, K & J Hills, lat. 25°–40′N, long. 91°–35′E, alt. 1311 m, rainfall 2083 mm.

Design and layout: Randomised block design with three replications and 36 plants per plot, planted at 2.5 × 2.5 m spacing.

The area was cleared of the existing vegetation during April–May, 1974 and pits of 30 × 30 × 45 cm were dug up as per treatments in June, 1974. The seeds of various provenance were sown in the nursery during October, 1972 and the nursery stock so raised in polythene bags was planted in the field during first week of August, 1974. The plants were maintained by usual weedings and obervations on growth and survival were recorded at quarterly intervals on the central 16 plants in each plot during March, June, September and December each year.

Results and discussion

1. *Height increment*: Initial height of the seedlings at the time of planting was recorded in August, 1974 and thereafter periodic observations on height growth were recorded at quarterly intervals. An abstract of the data on annual height increment is given in Table 1.

Table 1

Annual height increment of different provenances of chir pine and the exotic pines

Treatment	Initial height (cm)	Height increment in cm		
		Aug. 74–June, 75	July, 75–June, 76	July, 76–June, 77
T_1	43.66	14.25	14.24	49.94
T_2	30.94	17.58	14.26	34.51
T_3	33.26	11.73	14.38	48.96
T_4	46.61	11.15	21.58	70.08
T_5	35.38	11.99	14.22	48.09
T_6	39.16	12.93	11.54	48.68
T_7	31.94	11.18	16.33	50.24
T_8	37.09	11.17	15.09	51.90
T_9	33.22	18.78	21.42	69.84
T_{10}	35.29	17.51	11.74	46.54
T_{11}	39.86	13.79	24.23	66.65
T_{12}	30.69	14.52	13.80	50.44
T_{13}	31.52	29.05	25.84	90.48
T_{14}	61.06	29.16	47.63	120.34
T_{15}	26.94	24.15	25.10	105.54
SEM (±)	2.2488	2.7599	4.4724	6.9645
C.D. at 5%	6.5136	7.9937	12.9536	20.1713
	***	***	***	***

***Stands for significant at 0.1 % level.

Analysis of the data in Table 1 has shown that at the time of planting the initial height of *Pinus patula* seedlings was significantly better than all other specices/provenances. The height of *Pinus kesiya* was the lowest and out of the various provenances of *P. roxburghii*, the local provenance (T_4) was the best followed by its provenances from Nahan (T_1), Bilaspur (T_{11}), Dalhausie (T_6), Darkoti-Chamba (T_8) and Hamirpur (T_5), there being no significant difference between T_4 and T_1; or T_1, T_{11} and T_6; or T_{11}, T_6, T_8 and T_5.

The annual height increment during the first year after planting (1974–75) was significantly better in case of *P. patula* (T_{14}) followed by *P. caribaea* (T_{13}), and *P. kesiya* (T_{15}), there being no significant difference in between these three species. In case of *P. roxburghii*, the Saraj provenance (T_9) gave the best height increment followed by Bhaloor-Chamba (T_2) and the Kulu provenance (T_{10}), but there was no significant difference in height increment between all the twelve provenances of chir pine. The different provenances of chir pine gave significantly lower height increment during the first year as compared to *P. patula*, *P. caribaea* and *P. kesiya*.

Practically the same trend of height increment was maintained during the second year also. However, some of the provenances of chir pine showed enhanced height increment during the second year which resulted in non-significant difference in height increment between *P. caribaea*, *P. kesiya* and the provenances of chir pine, except its provenance T_{10} and T_6 which gave the lowest height increment.

During the third year of growth (1976–77) also *P. patula*, *P. kesiya* and *P. caribaea* maintained their superiority in height increment over the different provenances of chir pine. Between themselves the local provenance of chir pine (T_4) was best in height increment and was followed by the provenances from Saraj (T_9), Bilaspur (T_{11}), Darkoti-Chamba (T_8), Rajgarh (T_{12}), Tikri-Chamba (T_7) and Nahan (T_1), there being no significant difference in between these seven provenances of chir pine.

A critical appraisal of the data in Table 1 would show that *P. patula*, *P. caribaea* and *P. kesiya* exhibited superior height increment than the different provenances of chir pine during all the three years except that during the second year of growth (1975–76), there was no significant difference in height increment between *P. caribaea*, *P. kesiya* and the ten provenances of chir pine (excluding T_{10}, T_6).

The height increment within different provenances of chir pine varied from 34.51 cm (in T_2) to 70.08 cm (in T_4) during the third year. indicating a wide spectrum variability in the height increment of this species and suggesting the need for selection of suitable provenances for chir pine plantations. The local provenance (T_4) despite being poor in height increment during the first year after planting, picked up growth during the second year and maintained the trend in the third year as well, thus coming up from the last position (in descending order) in the first year to the 5th position in second year and fourth position in the third year. Similar trend was shown by the Darkoti-Chamba provenance (T_8) which came up from 14th position in first year to eighth position in second year and seventh position in the third year. The provenances T_2, T_{10} and T_5, however, showed a retreating trend from year to year. The provenances T_{12}, T_1, T_{11}, T_6, T_3 and T_7 were inconsistent in the height increment.

2. *Diameter increment*: The data on initial collar diameter and the subsequent annual diameter increment is given in Table 2.

Table 2

Annual diameter increment of different provenances of chir pine and exotic pines

Treatment	Initial collar diameter (cm)	Annual increment in collar diameter (cm)		
		Aug., 74–June, 75	July, 75-June, 76	July, 76–June, 77
T_1	0.83	0.98	2.25	2.72
T_2	0.56	0.62	2.08	2.34
T_3	0.57	0.80	1.59	2.73
T_4	0.56	0.87	2.43	2.53
T_5	0.60	0.77	1.95	2.33
T_6	0.69	0.71	2.00	2.76
T_7	0.59	0.87	2.01	2.38
T_8	0.64	0.98	2.10	2.66
T_9	0.68	1.15	2.17	3.24
T_{10}	0.58	0.62	2.05	2.44
T_{11}	0.62	1.09	2.37	2.64
T_{12}	0.53	0.76	2.27	2.44
T_{13}	0.42	0.75	1.62	2.60
T_{14}	0.61	0.84	1.57	3.86
T_{15}	0.51	0.61	2.18	3.81
SEM (±)	0.0387	0.1161	0.2073	0.2622
C.D. at 5 %	0.1120	0.3364	N.S.	0.7596
	***	**		***

***Stands for significant at 0.1 % level.

**Stands for significant at 1% level.

N.S.-Stands for not significant.

It can be seen from Table 2 that initial collar diameter of the Nahan provenance (T_1) of *P. roxburghii* seedlings was significantly better than all other provenances/species. *P. caribaea* had significantly poor collar diameter followed by *P. kesiya* and the Rajgarh provenance of chir pine, there being no significant difference in between themselves.

During the first year of growth (1974-75) the Saraj provenance of chir pine (T_9) gave significantly higher diameter increment and was followed by the Bilaspur (T_{11}), Darkoti-Chamba (T_8), Nahan (T_1), Dehra Dun (T_4), Tikri-Chamba (T_7) provenances of chir pine and *P. patula* (T_{14}), there being no significant difference in between these seven treatments. *P. kesiya* was the poorest in diameter increment.

During the second year (1975–76), the different provenances and species of pine had no significant difference in diameter increment from one another.

During the third year (1976–77), *P. patula, P. kesiya* and the Saraj provenance of *P. roxburghii* (T_9) gave significantly better diameter increment than the others, there being no significant difference in between themselves (T_{14}, T_{15}, T_9). So far as the other provenances of chir pine and *P. caribaea* are concerned they did not depict any significant difference in height increment amongst themselves.

A closer look at the data in Table 2 would show that though *P. kesiya* was the poorest in diameter increment during the first year, it showed a sudden spurt in diameter increment during the second year and maintained this trend during the third year also, thus coming up from the fifteenth position (in descending order) in the first year to fifth position in the second year and second position in the third year. It will be interesting to note that *P. patula* fell from seventh position in the first year to the last position in the second year but came up all the way to the first position in the third year. Similar erratic behaviour was shown by the Saraj (T_9), Kulu (T_3), Dehra Dun (T_4), Rajgarh (T_{12}), Bhaloor–Chamba (T_2) provenances of chir pine and *P. caribaea* of Cuba (T_{13}). The Dalhausie provenance of chir pine (T_6) came up from 12th position in the first year to 11th position in the second year and 4th position in the third year, showing thereby a steadily increasing trend in diameter increment similar to *P. kesiya* (T_{15}). The Tikri–Chamba (T_7) and Hamirpur (T_5) provenances of chir pine showed a consistently retreating trend in diameter increment and the performance of Nahan (T_1) and Bilaspur (T_{11}) provenances was also somewhat similar from the second year onwards.

3. *Survival*: The data on survival percent recorded at the end of three years growth in June, 1977 is presented in Table 3.

Table 3

Survival per cent of different provenances of chir pine and exotic pines

Treatment	Species	Origin	Survival per cent
T_1	*Pinus roxburghii*	Majra	52.1
T_2	,, ,,	Chamba	68.8
T_3	,, ,,	Kulu	79.2
T_4	,, ,,	Dehra Dun	85.4
T_5	,, ,,	Hamirpur	85.4
T_6	,, ,,	Dalhausie	66.7
T_7	,, ,,	Tikri	79.2
T_8	,, ,,	Darkoti	77.1
T_9	,, ,,	Saing	81.3
T_{10}	,, ,,	Parbati Valley	62.5
T_{11}	,, ,,	Gochar	83.4
T_{12}	,, ,,	Rajgarh	70.9
T_{13}	*P. caribaea*	Batey, Cuba	50.0
T_{14}	*P. patula*	Newzealand	39.6
T_{15}	*P. kesiya*	Meghalaya	22.9
SEM (±)			9.1166
C.D. at 5%			26.4044 ***

***Stands for significant at 0.1% level.

Analysis of the data in Table 3 has shown that the different provenances of chir pine gave significantly better survival per cent than *P. kesiya* and the two exotic pines namely *P. caribaea* and *P. patula.* The local provenance of chir pine from Dehra Dun (T_4) gave the highest survival followed by the Hamirpur (T_5), Bilaspur (T_{11}), Saraj (T_9), Kulu (T_3), Tikri-Chamba (T_7), Darkoti-Chamba (T_8), Rajgarh (T_{12}), Bhaloor-Chamba (T_2), Dalhausie (T_6) and Parvati valley (T_{10}), there being no significant difference in survival per cent between different provenances of chir pine. This indicates that the indigenous chir pine is more adaptable to the local conditions in terms of survival than the exotic pines. While survival of some of the chir pine provenances (T_4, T_5, T_{11}, T_9) was above 80 per cent, the survival of exotic pines was below 50 per cent.

4. *Suitability Index*: In order to assess the overall performance of different provenances/species under Dehra Dun conditions, a suitability index was worked out on the basis of height growth, collar diameter and survival per cent recorded at the end of three years growth in June, 1977, by giving 10 points to the greatest value of each parameter and finding the total score for each treatment as given in Table 4.

Table 4

Suitability index of different provenances of chir pine and exotic pines

Treatment	Scoring out of 10 points			Total score
	Height	Diameter	Survival	
T_1	4.149	7 047	6.101	17.297
T_2	2.867	6.062	8.056	16.985
T_3	4.068	7.072	9.274	20.414
T_4	5.823	6.554	10 000	22.377
T_5	3.996	6.036	10.000	20.032
T_6	4.045	7.150	7.810	19.005
T_7	4.175	6.166	9.274	19.615
T_8	4.313	6.891	9.028	20.232
T_9	5.803	8.394	9.519	23.716
T_{10}	3.867	6.321	7.318	17.506
T_{11}	5.538	6.839	9.766	22.143
T_{12}	4.191	6.321	8.302	18.814
T_{13}	7.519	6.736	5.855	20.110
T_{14}	10.000	10.000	4.637	24.637
T_{15}	8.770	9.870	2.681	21.321

It can be seen from Table 4 that *P. patula* (T_{14}) gave the highest suitability index of 24.6 and was closely followed by the Saraj provenance of chir pine (T_9) with a suitability index of 23.7. The other provenances in the descending order of suitability index are Dehra Dun (T_4), Bilaspur (T_{11}) provenances of chir pine, *P. kesiya* and Kulu (T_3), Darkoti-Chamba (T_8)

provenances of chir pine and *P. caribaea* (T_{13}). It can thus be seen that the Saraj (T_9), Dehra Dun (T_4) and Bilaspur (T_{11}) provenances of chir pine gave higher suitability index as compared to *P. kesiya* and *P. caribaea*.

Conclusions

It is bit too early to arrive at any definite conclusions about the suitability of the different provenances of pines tried under the present experiment. However, based on the results of the first three years growth after planting in the field, the following interim results are indicated.

1. *Pinus patula, P. caribaea* and *P. kesiya* gave significantly better height increment than the different provenances of chir pine (*P. roxburghii*), during all the three years, except that during the second year of growth there was no significant difference in height increment between *P. caribaea, P. kesiya* and ten provenances of chir pine (excluding T_{10}, T_6).

2. At the end of three years growth, *P. patula, P. kesiya* and the Saraj provenance of *P. roxburghii* (T_9) gave significantly better diameter increment than the others, there being no significant difference between these three. The Dalhausie (T_6) and Nahan (T_1) provenances of chir pine also showed promising diameter increment.

3. Different provenances of chir pine gave significantly better survival per cent than *P. kesiya* and the two exotic pines namely *P. caribaea* and *P. patula*. While survival of some of the chir pine provenances was above 80 per cent, the survival of the exotic pines was below 50 per cent.

4. Based on the overall performance in terms of height growth, collar diameter and survival per cent, *P. patula* gave the highest suitability index and was closely followed by the Saraj provenance (T_9), Dehra Dun provenance (T_4) and the Bilaspur provenance (T_{11}) of chir pine. *P. kesiya* and *P. caribaea* attained lower suitability index as compared to these provenances of chir pine (T_9, T_4, T_{11}).

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SUMMARY

An experiment having 15 treatments comprising of twelve provenances of chir pine (*Pinus roxburghii*) and one provenance each of *P. caribaea, P. patula* and *P. kesiya* was laid out in a randomized block design with three replications and 36 plants per plot at the Forest Research Institute, Dehra Dun (India) during 1974, to select suitable provenances/species for afforestation under the sub-Himalayan conditions. The results of the study at the end of three years growth show that *P. patula, P. caribaea* and *P. kesiya* gave significantly better height increment than the different provenances of chir pine. The Dalhausie, Kulu, Nahan, Darkoti–Chamba and Bilaspur provenances of chir pine gave better diameter increment than *P. caribaea*, but these

provenances of chir pine were inferior in diameter increment to *P. patula* and *P. kesiya*, there, however, being no significant difference in diameter increment betweeen *P. patula*, *P. kesiya* and the Saraj provenance of chir pine. Different provenances of the indigenous chir pine gave significantly better survival per cent than the three exotic pines under trial. Based on the overall performance in terms of height and diameter growth and survival per cent, *P. patula* was adjudged as the best species followed by the Saraj, Dehra Dun and Bilaspur provenances of chir pine.

पाइनस कैरिबिया, *पा० पैटुला* और *पा० केसिया* के मुकाबले में उप-हिमालय क्षेत्र में देशी चीड़ के विभिन्न उत्पत्तिस्थल विभेदों की कार्यशीलता

लेखक आर०सी० घोष, बख्शी सिंह, के०के० शर्मा व यू०डी० ढौंडियाल

सारांश

15 उपचारों वाला एक संपरीक्षण, जिसमें देशी चीड़ (*पाइनस राक्सबर्घिआई*) के बारह उत्पत्तिस्थल विभेद तथा *पाइनस कैरिबिया*, *पा० पैटुला* और *पा० केसिया* का एक-एक उत्पत्तिस्थल विभेद लिए गये थे, तीन दुहरावों के समसंभाविक खण्ड आकल्प में प्रत्येक भूमिखण्ड में 36 पादप रखकर, वन अनुसंधान संस्थान, देहरादून (भारत) में 1974 के दौरान उप-हिमालयी क्षेत्र जैसी दशाओं में वन रोपण के लिए उपयुक्त उत्पत्तिस्थल विभेद जाति का चुनाव करने के लिए तैयार किया गया। तीन वर्ष तक पौधों की वृद्धि होते रहने के बाद इस अध्ययन के परिणामों से यह पता चलता है कि ऊंचाई संवृद्धि से देशी चीड़ के विभिन्न उत्पत्तिस्थल विभेदों के मुकाबले में *पा० पैटुला*, *पा० केरिबिया* और *पा० केसिया* से सार्थक श्रेष्ठतर परिणाम मिले। डलहौजी, कुलू, नाहन, दारकोटी-चंबा और बिलासपुर उत्पत्तिस्थलों की चीड़ में व्यास संवृद्धि *पा० कैरिबिया* से अधिक रही परन्तु व्यास और संवृद्धि में ये उत्पत्तिस्थल विभेद *पा० पैटुला* और *पा० केसिया* से घटिया निकले किन्तु *पा० पैटुला*, *पा० केसिया* और देशी चीड़ के सिराज उत्पत्तिस्थल विभेद की व्यास संवृद्धि में कोई खास (सार्थक) अन्तर नहीं था। देशी चीड़ के विभिन्न उत्पत्तिस्थल विभेदों में, इस परीक्षण में, तीनों विदेशी चीड़ों से अतिजीविता प्रतिशत सार्थकतः श्रेष्ठतर रहा। ऊंचाई और व्यास वृद्धि और अतिजीविता प्रतिशत विचार से समग्र कार्यशीलता को लेने पर *पा० पैटुला* को इस कार्य के लिए सबसे अच्छी जाति पाया गया जिसके पश्चात् देशी चीड़ के सिराज, देहरादून और बिलासपुर उत्पत्तिस्थल विभेदों की गिनती आती है।

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DISTRIBUTION OF ORGANIC MATTER IN *PINUS ELLIOTTII* PLANTATIONS

By

O.N. Kaul, R.P. Singh, V.K. Srivastava and K. Gurumurti

Forest Research Institute & Colleges, Dehra Dun

Introduction

Pinus elliottii Engelm var. *elliottii* (slash pine) a tree of the Coastal Plains of subtropical North America is being widely planted because of its fast growth, attaining a mean annual increment of 30 to 40 m³/ha on good sites and 20 to 25 m³/ha even on relatively poor sites (Cozzo, 1961). The species was introduced, on an experimental basis, at Forest Research Institute, Dehra Dun in 1938 and thereafter small scale experimental plantations were raised in 1948, 1958 and 1968. It was found to grow faster as compared to the local subtropical pine—*Pinus roxburghii*.

Though some volume tables have been worked out (unpublished) for *P. elliottii*, studies on biomass, growth rates, litter production and turnover and cycling of minerals are lacking. The distribution of organic matter in *P. elliottii* plantations of 10, 20, 30 and 40 years of age is the subject matter of this paper.

Plantation details

The plantations were raised in the Demonstration Area of Forest Research Institute, Dehra Dun (30°21′40″ N latitude; 640 m elevation; moist deciduous forest). The site is old agricultural land consisting of alluvial soil overlying boulder conglomerate rock at depths ranging from 2 to 2.5 m. The soil is non-calcareous, ferruginous sandy loam to loam and is fertile in the top layer owing to addition of organic matter through forest litter. The average annual rainfall is about 2,060 mm and average annual temperature is of the order of 20°C; average maximum and minimum temperature being 28°C and 13°C respectively. The bulk of the rainfall (about 90 per cent) occurs during the monsoon months of June to September with a few premonsoon showers and a short winter rainfall during December to March. The main crop consists of an evenaged pure stand of *P. elliottii*, located in a moist deciduous forest (*Shorea robusta*) with practically no undergrowth except some annuals.

Four plantations of 10, 20, 30 and 40 years of age were sampled in 1978. These plantations were originally raised in 1968, 1958, 1948 and 1938 and occupy an area of 0.051, 0.057, 0.048 and 0.047 ha respectively. Table 1 shows the details of these plantations.

Methods

All the trees standing in the four plantations were enumerated and their diameters recorded. The whole diameter range, in each plantation, was divided into three diameter classes (Table 2) which are designated as Class A, B and C for simplicity of reference. Heights of a few standing trees (in each plantation) representing the whole range of diameters were also recorded and diamater/height curves drawn to get the mean height of each crop and for each diameter class within the plantations.

Table 1

Details of plantations

	Age (years)			
	10	20	30	40
1. Area of plantation (ha)	0.051	0.057	0.048	0.047
2. No. of trees	80	52	23	32
Class A	8	16	6	9
Class B	43	30	7	18
Class C	29	6	10	5
3. No. of trees/ha	1568	912	479	676
Class A	157	281	125	190
Class B	843	525	146	380
Class C	568	105	208	106
4. Mean diameter of the crop (cm)	13.9	20.3	28.3	31.0
Class A	7.8	13.2	16.3	22.9
Class B	12.8	22.0	27.0	32.4
Class C	17.4	30.0	36.5	40.7
5. Mean height of the crop (m)	11.0	18.3	21.3	23.0
Class A	7.6	15.9	16.5	19.9
Class B	10.6	18.6	20.9	23.3
Class C	11.9	19.6	23.3	24.3

Mean trees of the crops

Age (yrs.)	Diameter (cm)	Height (m)
10	13.9	11.0
20	20.3	18.3
30	28.3	21.3
40	31.0	23.0

Note : For details of diameter classes A, B, and C please refer to Table 2.

Table 2

Range of diameter classes

Age (yrs.)	Diameter class	Range (cm)
10	A	5–10
	B	11–15
	C	16–20
20	A	7–17
	B	18–27
	C	28–37
30	A	12–22
	B	23–32
	C	33–42
40	A	17–27
	B	28–37
	C	38–47

In each plantation, three sample trees (one from each diameter class), having diameters and heights close to the means of the three diameter classes, were felled and their above-ground biomass obtained. Thus, a total of twelve trees were felled in the four plantations under study. The parameters of the sample trees felled are shown in Table 3. It will be observed that in each plantation, the parameters of the mean tree (Table 1) are very close to the parameters of Class B sample tree (Table 3), and as such Class B sample tree, in each plantation, could be considered as mean tree of that plantation.

Table 3

Sample tree parameters

Age (yrs.)	Tree No.	Diameter class	D.B.H. (cm)	Height (m)
10	1	A	8.3	7.6
	2	B	13.5	10.7
	3	C	18.3	13.2
20	4	A	13.2	14.2
	5	B	21.3	18.8
	6	C	30.4	18.5
30	7	A	18.0	19.8
	8	B	28.3	21.1
	9	C	38.2	19.4
40	10	A	21.7	22.9
	11	B	32.7	24.2
	12	C	41.8	25.2

Fresh weights of all the components of sample trees were determined in the field by separating them into bole, bark, branches, twigs, leaves and cones. Representative samples of all the plant parts were oven dried to obtain their oven dry weights.

With regard to root biomass, root systems of two Class C sample trees (one each from 10 and 20 years) and two Class B sample trees (one each from 30 and 40 years) were extracted from one m^3 volume of soil around the main stem, and fresh and oven dry weights determined. No attempt was made to extract the roots from a larger area or to completely expose the root system of the sample trees, as most of the roots seemed to be confined to the upper one m of soil and there was heavy root fusion which made it difficult to distinguish between roots of individual trees.

Results and discussion

Individual tree dimension : These are evenaged plantations raised in a moist deciduous forest and grown under fairly uniform conditions with no other associate either in the tree canopy or as under growth except for some annuals. However, there is a wide variation in the growth of trees even within the same plantation. The diameter of trees in these plantations ranged from 4.6 to 20.6 cm (10 years), 7.0 to 34.6 cm (20 years), 12.6 to 42.1 cm (30 years) and 17.7 to 47.1 cm (40 years). Similarly the heights of the plantations vary from 5 to 12.6 m, 13 to 20.5 m, 14.5 to 24.5 m and 17 to 26 m in 10, 20, 30 and 40 years old plantations respectively.

The data of sample trees (Table 3) show that in all the four plantations, the mean diameter in the highest diameter class (Class C) is generally more than twice the mean diameter in the lowest diameter class (Class A). This is not the case with height growth, as the mean height growth in all the diameter classes within a plantation (20, 30 and 40 years) shows only slight variation though there is generally some increase in height gowth with increasing diameter. In the case of 10 years old plantation, height growth in Class C tree is nearly twice that of Class A tree. This differential growth pattern in an evenaged plantation may be partly due to genetical variation and partly to ecological or chance factors favouring certain seedlings in initial stages so that they grow relatively rapidly during early years to attain a more favourable position which influences tree form (Ovington and Madgwick, 1959).

However, as expected the mean crop diameter and height increased progressively with age in these plantations (Table 1). The mean crop diameter increased from 13.9 cm at 10 years to 31 cm at 40 years while the mean crop height increased from 11 m to 23 m during this period. The average diameter and height growth was therefore, more than doubled from 10 to 40 years.

Organic matter in sample trees

The oven dry weights of individual components of sample trees at different ages are presented in Table 4. There was considerable difference between fresh and dry weights of sample trees and their different components. In most of the tree components the moisture loss is between 40 to 50 per cent though in case of needles and twigs the losses are around 55 per cent. On an average there is about 45 per cent moisture loss on oven drying considering all the plant components of all ages together.

Table 4

Dry weights by tree components of sample trees (kg/tree)

Age (yrs.)	D.B.H. Class	Wood	Bark	Branch	Twig	Needles	Cones	Total	Root	Total
10	A	8.15	2.26	1.82	0.82	3.43	—	16.48	3.83*	20.31
		(49.4)	(13.7)	(11.1)	(4.9)	(20.8)				
	B	35.05	11.39	11.14	7.96	16.70	—	82.24	19.12*	101.36
		(42.6)	(13.9)	(13.6)	(9.7)	(20.3)				
	C	51.03	15.11	16.33	12.78	19.24	—	114.49	26.6	141.09
		(44.6)	(13.2)	(14.3)	(11.2)	(16.8)			(23.2)	
20	A	33.67	9.31	3.17	2.14	5.01	—	53.30	11.35*	64.65
		(63.2)	(17.5)	(5.9)	(4.0)	(9.4)				
	B	162.42	27.66	22.62	12.30	14.69	0.47	240.16	51.13*	291.29
		(67.6)	(11.5)	(9.4)	(5.1)	(6.1)	(0.2)			
	C	267.06	46.88	74.23	26.93	39.75	1.21	456.06	97.14	553.16
		(58.6)	(10.3)	(16.3)	(5.9)	(8.7)	(0.3)		(21.3)	
30	A	91.82	15.63	19.36	7.38	4.95	—	139.14	26.20*	165.34
		(66.0)	(11.2)	(13.9)	(5.3)	(3.6)				
	B	342.93	42.64	97.76	43.57	31.38	0.36	558.64	105.20	663.84
		(61.3)	(7.6)	(17.5)	(7.8)	(5.6)	(0.06)		(18.8)	
	C	383.80	69.46	123.88	31.30	33.67	0.59	642.70	121.03*	763.73
		(59.7)	(10.8)	(19.3)	(4.9)	(5.2)	(0.9)			
40	A	185.34	29.11	8.42	8.29	11.86	0.01	243.03	43.73*	286.86
		(76.2)	(12.0)	(3.5)	(3.4)	(4.9)	(0.004)			
	B	454.13	59.86	110.86	50.61	31.93	0.98	708.37	127.46	835.83
		(64.1)	(8.5)	(15.7)	(7.2)	(4.5)	(0.1)		(18.0)	
	C	844.99	87.76	223.69	40.23	58.43	0.97	1256.07	226.00*	1482.07
		(67.3)	(7.0)	(17.8)	(3.2)	(4.6)	(0.08)			

Note : (1) Figures in drackets indicate the percentage of the total above-ground dry weight.

(2) Figures marked with asterisk (*) are calculated values as roots were not sampled in these trees (see text).

Wood: As expected, the trees of higher diameter class within the same age have a higher wood biomass and this wood biomass also increases with age, the effect of increasing diameter and age being very pronounced. The wood weight increase is more than 6 times from Class A tree (8.15 kg/tree) to Class C tree (51.03 kg/tree) in 10 years old plantations; more than 7 and 4 times in 20 and 30 years old plantations respectively and from 185.34 kg/tree, (Class A) to 844.99 kg/tree (Class C) in 40 years old plantation.

Considering Class B sample trees at different ages as mean trees of respective plantations (as mentioned earlier), it is observed that wood biomass has increased more than 4.5 times from age 10 years (35.05 kg/tree) to age 20 years (162.42 kg/tree). Similarly the increase in wood weight has been more than twice from 20 to 30 years and more than 1.3 times detween 30 and 40 years.

Bark: Bark dry weight showed the same trend as that of wood with pronounced effect of diameter and age. The bark weight increased from 2.26 to 15.11 kg/tree (more than 7.5 times) from Class A tree to Class C tree at age 10 years. Similarly the increase was of the order of more than 5, 4 and 3 times at ages 20, 30 and 40 years from the lowest to the highest diameter.

The bark biomass of Class B tree at 10 years was 11.39 kg/tree which increased to 27.66, 42.64 and 59.86 kg/tree at age 20, 30 and 40 years respectively, thereby showing more than 600 per cent increase in bark weight in 30 years.

Branch: There is a marked increase in the branch dry weight with increasing diameter at each age. For example, there is nearly nine-fold increase in the branch dry weight from Class A tree (1.82 kg/tree) to Class C tree (16.38 kg/tree) in 10 year old plantation. Similarly the increase is of the order of 25, 6 and 26 times from the lowest to the highest diameter at ages 20, 30 and 40 years respectively.

With regard to the branch biomass of Class B tree at different ages, this increased from 11.14 kg/tree (10 years) to 110.86 kg/tree (40 years) showing a ten-fold increase in branch dry weight, in 30 years.

Twigs: As with the branch weight, twig dry weight has also shown a marked increase from the lowest to the highest diameter at each age. The twig dry weight increases nearly 12 times from Class A tree (0.82 kg/tree) to Class C tree (12.78 kg/tree) in 10 years old plantation. Similarly there is 13, 4 and 5-fold increase in twig dry weight at 20, 30 and 40 years from the lowest to the highest diameter.

The twig biomass of Class B tree (kg/tree) was of the order of 7.96, 12.30, 43.57 and 50.61 at 10, 20, 30 and 40 years respectively. It therefore, follows that twig weight increased 1.5 times from 10 to 20 years, 3.5 times from 20 to 30 years and 1.1 times from 30 to 40 years. Thus, the twig biomass increased more steeply between 20 and 30 years (3.5 times) which may be attributed to rapid closing of the canopy between these ages.

Needles: Total needle dry weight of sample trees exhibited considerable variation with diameter and age. The needle dry weight varied with diameter from 3.43 to 19.24 kg/tree (10 years), 5.01 to 39.75 kg/tree (20 years), 4.95 to 33.67 kg/tree (30 years) and 11.86 to 58.43 kg/tree (40 years). The needle dry weight thus increased 6, 8, 6 and 5 times between the lowest and the highest diameter at 10, 20, 30 and 40 years respectively.

As regards the needle biomass of Class B tree (mean tree at differents ages), it increased from 16.70 to 31.93 kg/tree from 10 to 40 years showing a two-fold increase in needle dry weight in 30 years.

Cones: Cones were absent in 10 years old plantation, but were found in trees of higher diameters in 20, 30 and 40 years old crops, as indicated in Table 4.

Total shoot: The total shoot weight (wood, bark branches, twigs and needles) increases with increasing diameter and age. Shoot dry weight increased more than 7 times from the lowest diameter (16.48 kg/tree) to the highest diameter (114.49 kg/tree) in 10 years old plantation. Similarly there is around 8, 4 and 5-fold increase in shoot dry weight at 20, 30 and 40 years from Class A to Class C tree.

The shoot dry weight of mean trees (Class B trees) varies as 82.24, 240.16, 558.64, and 708.37 kg/tree at 10, 20, 30 and 40 years age. Thus, there is more than 8.5 times increase in shoot dry weight within a 30 year period. The shoot dry weight, however, increases 2.9 times from 10 to 20 years, 2.3 times from 20 to 30 years and 1.3 times from 30 to 40 years. There is thus a decrease in the rate of accumulation with increasing age.

With regard to the contribution of different plant components to the total shoot weight, bole contributes the maximum in all tree classes at all ages varying on an average (Class B tree) from 42.6, 67.6, 61.3 and 64.1 per cent at 10, 20, 30 and 40 years respectively. There is, however, only slight variation in the percentage contribution of wood to the total shoot in different classes of trees within each crop. For example, the percentage contribution of wood between different classes of trees at 10 years varies from 42.6 (Class B) to 44.6 (Class C) to 49.9 per cent (Class A).

The per cent contribution of bark to that of total shoot biomass decreased with age; the decrease on the average being from 13.9 per cent at 10 years to 8.5 per cent at 40 years. Within the same age, per cent bark contribution shows a parallel variation as that of wood.

The contribution of branches and twigs to the total shoot weight shows almost similar trends both with respect to age and different diameters within the same age. On an average (Class B tree) branch contribution was 11.14 per cent at 10 years which decreased to 9.4 per cent at 20 years, again increased to 17.5 per cent at 30 years, while it was 15.7 per cent at 40 years. Similar increases and decreases at different ages are observed in the percentage contribution of twigs, which were as: 9.7, 5.1, 7.8 and 7.2 per cent at ages 10, 20, 30 and 40 years.

Within the same age, however, the percentage contribution of branches and twigs varied between different diameters.

With regard to the contribution of needle weight to the total shoot weight, on an average it dereases suddenly from 20.3 per cent at 10 years to 6.1 per cent at 20 years and thereafter gradually to 4.5 per cent at 40 years, suggesting thereby that more of the dry matter is partitioned into non-photosynthetic tissue especially wood with increasing age. There is very little variation in the percentage contribution of needle weight, between different diameters within the same age.

The per cent contribution of different plant components to total above-ground shoot weight at comparable ages compares well with—(i) 13 years old *Pinus taeda* plantation (Larsen *et al.*, 1976) with bole contributing 52 per cent, followed by branch and twig (20 per cent). needle (10 per cent) and bark (8 per cent); (ii) 16 years old *P. taeda* plantation (Jorgensen *et al.*, 1975) with bole contribution as 70 per cent, branch and twig 15 per cent, bark 10 per cent and needles 5 per cent; (iii) 30 years old *Pinus roxburghii* plantation (Seth *et al.*, 1963) with bole contributing 72 per cent, bark 17 per cent, and needles 10 per cent; and (iv) 44 years old *Pinus roxburghii* plantation (Kaul *et al.*, 1981) with bole contributing 70 to 80 per cent, branch 4 to 16 per cent, bark 7 to 9 per cent, needles 3 to 5 per cent, and twigs 2 to 4 per cent. However, in case of *Pinus radiata* (Orman and Will, 1960), bole contributes 80 per cent to total above-ground dry weight in a 30 years old plantation in New Zealand.

Root: As mentioned earlier root systems of only four sample trees (one from each age) were extracted from one cubic metre volume of soil around the main stem and the root dry weight of these sample trees are shown in Table 4. The root biomass of sample trees (kg/tree) increases from 26.6 (10 years) to 97.14 (20 years) to 105.20 (30 years) and to 127.46 (40 years). which is 23.2, 21.3, 18.8 and 18 per cent of the above-ground biomass of these trees respectively. These figures also indicate that root biomass is 19, 18, 16 and 15 per cent of the total biomass (both above and below-ground) at respective ages.

As only one root system from each plantation was sampled for estimation of root biomass, the figures of root biomass for other two sample trees of each plantation shown in Table 4 were calculated, based upon the ratio that the root biomass of the sampled tree bears to its above-ground biomass (e.g., 23.2 per cent in case of Class C tree at 10 years). This presumption may not be wholly correct and coupled with the fact that the entire root system of the sample trees were not extracted, the root biomass figures presented (Table 4) are rather approximate, possibly underestimates.

Total biomass: The sample tree data presented in Table 4 has been used to calculate the total biomass per ha at different ages (Table 5). The above-ground standing biomass of these plantations is of the order of 136,947; 189,186; 232,636 and 448,498 kg/ha at 10, 20 30 and 40 years of age showing an increasing effect of age, as expected. The same trend is observed in all the plant components with increasing age, except in twig and needle weight. The wood biomass has more than doubled from 10 to 20 years (59,812 to 122,935 kg/ha) and the rapid build-up of bole material continuous until at 40 years it is almost 5 times (297,351 kg/ha) the weight at 10 years. The overall weight of bark at each age continuous to increase as the stands mature though there is only a slight variation in bark weight at 20 and 30 years. Similarly, there is a continued increase in branch weight with increasing age, the branch biomass at 40 years (67,433 kg/ha) being 3.6 times more than that at 10 years.

There is a sharp decline in twig biomass from 10 years (14,098 kg/ha) to 20 years (9,899 kg/ha) which later increases with age. In cases of needles, however, the biomass sharply decreases from 10 years (25,548 kg/ha) to 20 years (13,307 kg/ha), decreasing further gradually to 12,204 kg/ha at 30 years and later increases to 20,580 kg/ha at 40 years. This variation in twig and needle biomass per ha may probably be attributed to the various densities of these plantations.

Seth *et al.* (1963) have reported a total abve-ground biomass of 68,517 kg/ha for a *Pinus roxburghii* plantation (30 years) raised in the same general area as the plantations under study, while Kaul *et al.* (1981) have observed an above-ground biomass of 145,146 kg/ha for the same species at 44 years. Switzer and Nelson (1972) in their studies on loblolly pine have found an above-groud biomass of 30,000 and 90,000 kg/ha at 10 and 20 years. For comparable ages, the figures of above-ground biomass observed in the present study are far higher than that of other studies just referred.

With regard to the percentage contribution of different plant components to the above-ground biomass, the percentage contribution of wood biomass increases from 43.7 (10 years) to 65 per cent (20 years) and thereafter is fairly constant with increasing age. A similar trend is observed in twigs. This is not however, the case with bark and needles, where the percentage contribution of these components drops with advancing age; the decrease being gradual in case of bark (13.5 per cent at 10 years to 8.4 per cent at age 40 years), while in case of needles, the drop is gradual after 20 years. The percentage contribution of branches varies with age but does not show any definite trend.

Too few roots were sampled to provide comprehensive data on the build up of root systems at different ages but it is clear that the total root weight (Table 5) increases with age; the root biomass having increased from 31,834 to 80,699 kg/ha (more than 2.5 times) from 10 to 40 years. The percentage contribution of root biomass to the above-ground biomass, however, decreases gradually with age, from 23.2 per cent (10 years) to 18 per cent (40 years) with a similar trend as regards the percentage contribution of root biomass to the total biomass (above and below-ground). The presence of root grafts between neighbouring trees suggests that when a tree dies or is removed, some of its roots may survive and become an effective part of the roots of other trees and it has also been considered that the roots of forest trees may not function individually as root grafts permit transfer of substances from one root to another (Ovington and Madgwick, 1959a).

Of the total biomass (above and below-ground), 81 per cent (10 years) to 85 per cent (40 years) is contributed by the above-ground parts and the balance of 19 to 15 per cent is from the tree roots. Jorgensen *et al.* (1975) have reported that in a 16 years old plantation of loblolly pine, the root biomass is 23 and 19 per cent of the above-ground biomass and total biomass respectively and needles and branches together contribute 16 per cent to the total tree biomass. Kaul *et al.* (1981) in their studies on *Pinus roxburghii* (44 years) have found that of the total biomass, nearly 80 per cent is contributed by the above-ground parts and the balance of 20 per cent by roots. These results are almost similar to the results of the present study.

The figures of above-ground biomass and total biomass per tree for different ages are shown in Table 5. The above-ground biomass per tree has increased more than 7 times—from 87 kg at 10 years to 663 kg at 40 years. The rate of increase has been more than double from 10 to 30 years and has slowed down thereafter. The same trend is observed in the total biomass (above and below-ground per tree).

The rate of accumulation of dry matter (kg/ha/year) in the non-photosynthetic tree components including roots, continues to decline gradually with increasing age upto 30 years and thereafter increases again, the rate at 40 years being 12,715 kg/ha/year (Table 5). This

Table 5

Total standing biomass (kg/ha)

Age (yrs.)	10	20	30	40
No. of trees/ha	1568	912	479	676
Wood	59812	122935	141376	297351
	(43.7)	(65.0)	(60.8)	(66.3)
Bark	18537	22088	22627	37580
	(13.5)	(11.7)	(9.7)	(8.4)
Branch	18952	20583	42460	67438
	(13.8)	(10.9)	(18.2)	(15.0)
Twig	14098	9899	13794	25071
	(10.3)	(5.2)	(5.9)	(5.6)
Needle	25548	13307	12204	20580
	(18.6)	(7.0)	(5.2)	(4.6)
Cone	—	374	175	477
		(0.2)	(0.1)	(0.1)
Total above ground biomass	136947	189186	232636	448498
Root	31834	40283	43808	80699
	(23.2)	(21.3)	(18.8)	(18.0)
Total Biomass	168781	229469	276444	529197
Above ground biomass/tree	87	207	486	663
Total biomass/tree	108	252	577	783
Productivity				
Non-photosynthetic above ground biomass (kg/ha/yr.)	11140	8794	7348	10698
Non-photosynthetic root biomass (kg/ha/yr.)	3183	2014	1460	2017
Total	14323	10808	8808	12715
Non-photosynthetic above ground biomass (kg/tree/yr.)	7	10	15	16
Non-photosynthetic root biomass (kg/tree/yr.)	2	2	3	3
Total	9	12	18	19

Note : Figures in brakets indicate the percentage of total above ground dry weight.

differential productivity can be attributed to different tree densities of these plantations and hence valid comparisons on area basis are rather difficult. However, the annual rate of accumulation of organic matter in non-photosynthetic above-ground and total biomass on a per tree basis continues to increase with age (Table 5), the above-ground and total rate of accumulation having more than doubled from 10 years (9 kg/tree/year) to 40 years (19 kg/tree/year). There has been only a marginal increase in the productivity of root biomass, with age. Kaul *et al.* (1981) have reported a total rate of accumulation of non-photosynthetic biomass (both above and below-ground) as 14 kg/tree/year in a *Pinus roxburghii* plantation (44 years) raised adjacent to the plantations under study, while Larsen *et al.* (1976) have observed a mean annual rate of accumulation of 4.7 kg/tree (above-ground biomass only) in a loblolly pine plantation (13 years) in U.S.A. These annual rates of accumulation are lesser than those obtained in the present study for comparable ages.

SUMMARY

The distribution of organic matter in various tree components for 10, 20, 30 and 40 years old plantations of *Pinus elliottii* has been discussed. The total biomass ranges from about 169 tonnes (10 years) to 529 tonnes (40 years) per ha with 81 to 85 per cent being contributed by the above-ground parts and 19 to 15 per cent by the roots.

पाइनस इलियटिआई रोपवनों में जैव पदार्थ का वितरण

लेखक ओ०एन० कौल, वी०के० श्रीवास्तव **व** के० गुरुमूर्ति

सारांश

इस अभिपत्र में 10, 20, 30 और 40 वर्षीय रोपवनों में *पाइनस इलियटिआई* वृक्षों के विभिन्न भागों मे जैव पदार्थ के वितरण का विवेचन किया गया है। संपूर्ण जैवपुंज लगभग 169 टन (10 वर्ष) से 529 टन (40 वर्ष) प्रति हेक्टेयर के बीच में आता है जिसका 81 से 85% भाग भूमि से ऊपर वाले भागों में तथा 19 से 15 प्रतिशत भाग जड़ों से मिलता है।

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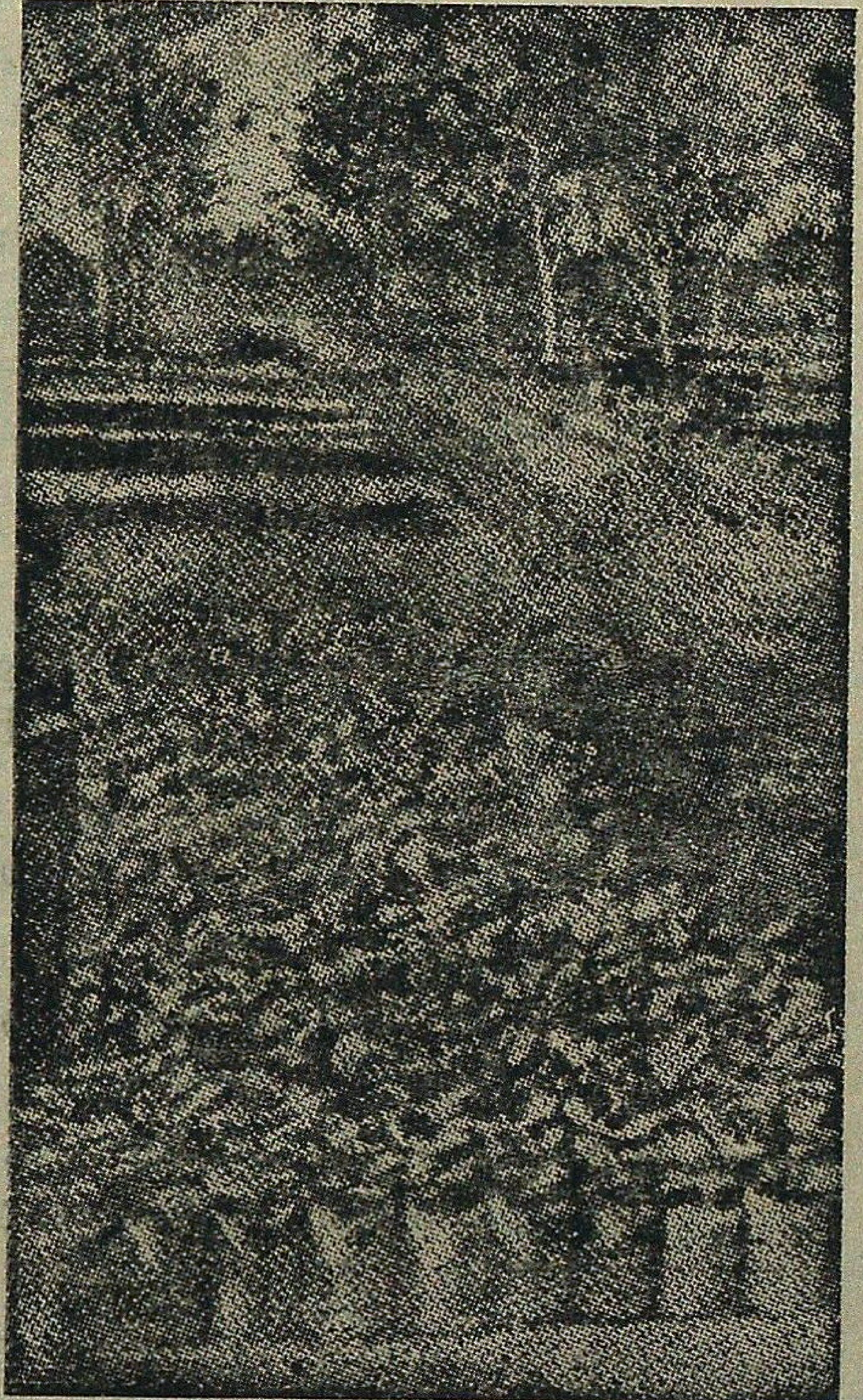

STUDIES ON PINE MYCORRHIZA IN NURSERY SEEDLINGS

By

H.S. Thapar* and D.P. Paliwal†

Introduction

Tropical pines have great potential in India as a valuable source of long fibred material for pulp and paper industry. When planted as exotics out side their natural homes, all pines require establishment of mycorrhiza on their roots for their survival in the field. In natural pine zone, exotic pines generally pick up mycorrhiza with the local species of fungi present in the site but in areas devoid of pines and treeless regions introduction of appropriate mycorrhizal symbionts becomes necessary as in dome areas of central India, Orissa, Andhra Pradesh and grasslands in Tamil Nadu. Afforestation of degraded and sub-marginal sites poses serious problems of survival, establishment, poor growth due to stagnation and sometimes plantation failures reported from several parts of the world (Briscoe 1959; Gibson 1960; Gilmour 1958; Harley 1959; Lundquist 1964).

These problems can be overcome only if seedlings are adequately colonised by ectomycorrhizal fungi at planting sites. Mycorrhiza is also important for improving the quality of planting stock in the nursery and successful establishent of pines on sub-marginal sites as they aid in better nutrient absorption particularly in deficient soils. In the present study extensive surveys were conducted in major pine nurseries in Andhra Pradesh, Orissa, Madhya Pradesh, Tamil Nadu and Uttar Pardesh, to determine the status of mycorrhiza in seedlings, identify the mycorrhizal fungi and categorise the different mycorrhizal infections occurring in different areas in the different species.

Mycorrhizal Status

Establishment of mycorrhiza in pines is dependent on the effectiveness and source of soil inoculum, its proportion in the potting mixture, nutritional status, pH and moisture regime (soil moisture). Such details were collected for each nursery and status of mycorrhiza in relation to these factors was recorded. Details of different practices prevailing in nurseries are given as below :-

1. Uttar Pradesh—Tropical pine nursery, New Forest.

Potting mixture—Soil and sand 3 : 1

pH 7.8

Soil treatment—		
	Super phosphate 1 kg.	Per m³ soil
	Bone meal 1 kg.	
	Sulphur 500 g.	

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Method of inoculation—pine soil is bulked in potting mixtre.
Source of inoculum—Adjoining chir pine stands.

2. Orissa—Daringibadi, Kalinga, Koraput and Pottangi
Potting mixture—Local soil and sand in 40 : 60
pH 5.5 to 6.8

Soil treaatment—Rock phosphate-1 kg per m^3 soil.

Method of inoculation—Bulking.

Source of inoculum—Adjoining pine plantations in the research gardens.

3. Andhra Pradesh-Tirumala
Potting mixture—Local nursery soil mixed with sand and drainage soil in equal proportion.
pH 6.5
Soil treatment—Not attempted.
Method of inoculum—Individual inoculation of tube seedlings.
Source of inoculum—Top pine soil under pine plantations at Araku.
Anjodha—
Potting substrate—Soil mixed with humus (sterilized).
pH 6.6

Soil treatment—NPK fertilizer 5 g.
Super phosphate 50 g.
Magnesium sulphate 50 g.
Bone meal 50 g.
Borax 1 g.
Rock phosphate 100 g.
Sulphur 5 g.
per cubic foot.

Method of inoculation—Individual inoculation of tubes.
Source of inoculum—Successful pine stands in research garden at Araku.
Paderu, Chompi, Kitumala, Chintapalli and Maredumilli.
The substrate is same in all nurseries. Mycorrhizal inoculum is obtained from pine trees in research garden at Araku and is introduced in the planting holes at the time of planting.

4. Madhya Pradesh : Kurandhi—
Potting mixture sand soil 2 : 1
pH 6.6–6.8.

Soil treatment single granular super phosphate 1 kg. Horn flakes and bone meal in equal proportion per m^3 soil copper sulphate as drench 0.2% and Phytolan spray at monthly intervals.

Method of inoculation—Individual inoculation of tubes.

Source of inoculum—Pine Plantations at Jagdalpur.

Amarkantak—

Potting mixture—Local broad leaf soil and sand—4 : 1
pH 6.0–7.0
Soil treatment—Not attempted.
Method of inculation—Individual inoculation of tubes.
Source of inoculum—Pine plantation at Jagatpur.

5. Tamil Nadu : Karamanthurai (Kalarayan Hills)

Potting mixture—Local soil and sand 3 : 1
pH 7.65
Soil treatment—Not practiced.
Method of inoculation—Not attempted.

Kolli Hills

Potting mixture—local nursery soil of broad leaf species.
pH 5.6
Soil treatment—Not attempted.
Method of inoculation—Individual inoculation of tubes
Source of iuoculum—Adjoining 1972 *Pinus caribaea* plantations.

Perumalmalai

Potting miture—Local soil under hardwood species.
pH 5.7
Soil treatment—Not attempted.
Method of inoculation—Bulking pine soil in potting mixture.
Source of inoculum—Successful pine stands adjoining nursery.

Nilgiris Hill Nurseries (Governor shola, Carin Hill, Parson's Valley, Talakunda, Pykara)

Potting mixture—Local soil, Shola earth and sand 4 : 1 : 1
pH 5–6
Soil treatment—Not attempted.
Method of inoculation Bulking.
Source of inoculum—Adjoining pine plantations.

Kargudi (Gudalur)

Potting mixture—Local soil (under broad leaf) + farmyard manure.
pH 6.0
Soil treatment—Not attempted.
Method of inoculation—Not attempted.

Status of mycorrhiza in the nurseries in given in Table 1.

Table 1

Mycorrhizal status in nurseries

Locations	Alitude (m)	Species	Age (month)	Mycorrhizal status	Type/form
1	2	3	4	5	6
1. Uttar Pradesh					
New Forest	670	*P. caribaea* *P. kesiya* *P. oocarpa* *P. patula*	10	Poor	Ecto–1, 2, 3, 6, 7
2. Orissa					
Daringibadi	945	*P. insularis* *P. oocarpa*		Absent	
Kalinga	701	*P. caribaea* *P. elliottii* *P. kesiya* *P. oocarpa* *P. merkusii*	6	Abundant	Ecto–2, 3, 4, 5, 6
Koraput	851	*P. caribaea* var. *hondurensis* -do- (Guatemala) (Alamicamba) *P. elliottii* (Queensland) *P. kesiya* (Philippines) *P. merkusii* (Zambia) *P. oocarpa* (Mountain Pine)	18	Poor	Ecto and Ectendo–2, 3, 7
Pottangi	930	*P. caribaea* *P. kesiya* *P. merkusii* *P. oocarpa*	8	Abundant	Ecto and Ectendo–3, 7
3. Andhra Pradesh					
Tirumala	950	*P. caribaea* *P. kesiya* *P. merkusii* *P. patula*	10-12	Abundant	Ecto–3

(*Contd.*)

Table 1 (*Contd.*)

1	2	3	4	5	6
Araku (Anjodah)	1100	*P. caribaea* *P. occidentalis* *P. greggii* *P. kesiya* *P. montezumae*	1	Poor	Ecto and Ectendo-3
Paderu	1000	*P. caribaea* *P. kesiya*	10	Absent	—
Chompi		*P. caribaea*	10	Absent	—
Kitumala	850	*P. caribaea*	10	Absent	—
Chintapalli	800	*P. caribaea* *P. greggii* *P. kesiya* *P. oocarpa* *P. roxburghii*	10	Absent	—
Maredumilli	400	*P. caribaea* *P. kesiya* *P. oocarpa* *P. rudis*	8	Absent	—
Forest Corp. Nursery Valamusttlavada	400	*P. kesiya* *P. roxburghii* *P. oocarpa*	10	Present	Ecto
Madan Kunj		*P. caribaea* *P. kesiya* *P. patula* *P. occidentalis*	10	Present	Ecto
4. Madhya Pradesh					
Amarkantak	1100	*P. caribaea* *P. roxburghii*	7	Absent	—
Jagdalpur	700-1100	*P. caribaea* *P. elliottii* *P. greggii* *P. oocarpa* *P. merkusii*	10–12	Abundant	Ecto-2, 3
5. Tamil Nadu					
Palni hills					
Kalrayan Hills (Karamanthurai)	800	*P. caribaea* *P. oocarpa*	5	Absent	—

(*Contd.*)

Table 1 (*Conld.*)

1	2	3	4	5	6
Kolli Hills	1190	*P. caribaea* *P. oocarpa*	5	Abundant	Ecto–4
Perumalmalai	1400	*P. caribaea* *P. oocarpa* *P. patula*	6	Occasional	Ecto and Ectendo
Berijam	2500	*P. patula*	7	Occasional	Ectendo
Gundar	2000	*P. caribaea* *P. elliottii* *P. oocarpa* *P. patula* *P. pseudostrobus*	6	Occasional	Ecto -6
Poombari	2100	*P. patula*	5–9	Present	Ecto–6
Pulvachar	2240	*P. patula*	7	—	
Kaluthai Odai	2240	*P. patula*	12	—	
Niligiris (Ooty)					
Muthorai	2250	*P. patula* *P. pseudostrobus*	10		
Governor Shola	2250	*P. patula*	10	Present	Ecto–6
Carin Hill	2250	*P. patula*	10	Present	Ecto–6
Parson's Valley	2400	*P. oocarpa* *P. patula*	12	—	—
Tala Kunda	2200	*P. patula* *P. pseudostrobus*	6	Present	Ecto–6
Pykra	2054	*P. patula*	12	Present	Ecto-6
Kargudi Nursery (Gudalur)	1048	*P. caribaea* *P oocarpa*	10–12	Present	Ecto–6

Mycorrhizal types

The mycorrhizae correspond to description of Melin's (1927) type A and diffused infected system described in beech (Harley, 1959). Type C (Nodular) mycorrhiza and black type (DN) with radiating hyphae were, however, absent in nursery seedlings.

Infection forms

Seven forms of mycorrhizal infection under Melin's Type A and described below were observed. The fungus sheath was devoid of oranamentations (Cystidis, Setose hyphae).

Form 1. Mantle pale yellow, loose hyphal, 4-5 cell layered, 25–30 μ thick with spreading hyphae thin-walled, clamped 1.5–2.5 μ broad.

The fungal symbiont is identified as *Scleroderma bovista* and forms mycorrhiza in *Pinus caribaea*, *Pinus elliottii*, *Pinus kesiya* seedlings at New Forest Nursery.

Form 2. Mantle brown, pseudoparenchymatous, compact, thick. smooth without projecting hyphae, 7–10 cell layered, 27–42 μ thick with a deeply stained smoky brown to deep brown peripheral layer. Cells in the inner layer nearly oval. Hyphae in mantle brown, simple septate, thick-walled, 4–6 μ in diameter (Figs. 1, 7, 8, 9). The fungus symbiont is common in *P. caribaea* and *P. kesiya* nursery seedlings and in plantations at Koraput.

Form 3. Mantle, pale to pale brown, short cellular to pseudoparenchymatous, 4–8 cell layered, 15–28 μ thick with hyphae projecting from the periphery of the mantle often granulated and knobed at apex. Hyphae in mantle simple septate, clamped, thick-walled, 2.5–3.5 (– 4 μ) in diameter (Figs. 2, 4).

The fungus symbiont is recorded in *Pinus roxburghii* seedlings in mycorrhizal bank at Koraput. Similarly infection type is observed in *P. caribaea* seedlings at a New Forest. The symbiont is identified as *Amanita hemibapha* and is found to be a mycorrhiza forming species in *Pinus caribaea*, *P. greggii* and *P. michocana* seedlings at Koraput and Arku (Anjodah) nurseries.

Form 4. Mantle hyaline, to pale, mycelial, smooth, compact, 5–6 cell layered, 17–20 μ thick. Hyphae in mantle, pale, thick-walled, simple septate wiih deposits, 1.75 μ in diameter (Figs. 3, 12) The symbiont forms a common mycorrhizal associate of *P. caribaea* seedlings at Kolli Hills and *P. kesiya* at Kalinga.

Form 5. Mantle greyish-brown, loose mycelial, 8–10 cell layered, 24 μ thick. Hyphae in mantle hyaline, slightly thick-walled simple septate with deposits (Fig. 5). The symbiont is associated with *P. oocarpa* mycorrhiza at Kalinga.

Form 6. Mantle hyaline to greyish, mycelial with loose hyphae, 10-14 cell layered, 27-60μ thick. Hyphae in mantle hyaline, smooth, thick-walled, clamped, 3.45–5.20 μ in diameter (Figs. 6, 11). The symbiont is present in Kalinga and Gundar nursery seedlings.

Form 7. Mantle Pale brown, mycelial to loose hyphal, 17–25 μ thick, hyphae in mantle pale, smooth, thick-walled with narrow lumen, asepatate, 1.75 μ in diameter (Fig. 10). The symbiont is associated with *P. kesiya* seedlings in mycorrhizal bank at Koraput.

Out of seven forms described above, only one form compares with the forms described in Chir pine (*Pinus roxburghii* Sargent) from New Forest (Bakshi & Thapar 1966).

Conclusion

On the basis of above observations it may be concluded that both ecto and ectendo mycorrhizae occur in nursery seedlings in some locations. It may be mentioned that ectendotrophism is predominent in nurseries established on agricultural lands subjected to intensive fertilization or in old forest nurseries established on arable lands. The beneficial effects of ectendo mycorrhiza on growth responses in plants are disputed and therefore, only ecto-mycorrhizal induction is advocated in forest nurseries. The study further reveals that :

1. Inspite of regular practice of mycorrhizal introduction using soil inoculum there is a general deficiency of ecto-mycorrhiza in nursery seedlings. Wherever present, the mycorrhizal development was delayed, erratic and inadequate in most cases. Irregular and poor development of mycorrhiza in seedlings could possibly be due to inadequate proporation of mycorrhizal soil in the potting mixture, bulking the inoculum which does not always ensure uniform mixing of inoculum and also lack of active propagules of mycorrhizal fungi (short root clusters) through which infection is known to spread quickly as observed in nursery seedlings in the Tamil Nadu State.

2. Delayed development of mycorrhiza in pine seedlings at New Forest nursery where pine soil is used for preparing potting mixture is due to high soil pH and high free calcium carbonate content of sand and alkaline irrigation water. Sand of high pH may therefore, be avoided for preparing the potting mixture as high pH is known to be unfavourable for mycorrhizal development and growth of pines and some times complete replacement or absence of mycorrhizal infections.

3. Phosphate fertilizer and compost (farm yard manure) was found to promote mycorrhizal development in nursery stocks at Kurandhi (Jagdalpur), Pottangi (Koraput) and some nurseries in Palni and Nilgiri Hills in Tamil Nadu State which exhibited vigorous growth and dark green lustre. However, in some cases, poor mycorrhizal development inspite of application of super phosphate and compost as at New Forest, Koraput and Anjodah (Andhra Pradesh) could be due to poor mycorrhiza forming ability of local mycorrhizal symbionts or unfavourable soil conditions in the absence of soil amendments.

In the natural pine zone in India DN type mycorrhiza due to *Cenococcum graniforme* which is one of the common symbionts was found to be absent in the nursery soils probably due to high soil moisture. The presence of some common infection forms in New Forest seedlings and dome areas is indicative of the successful establisment of these fungi in exotic locales through seedling transfer.

The absence of loose weft infections due to *Scleroderma bovista* in the red lateritic soils of Andhra Pradesh, Orissa, and lateriticpeaty soils of Tamil Nadu could be due to restricted distribution of this fungus and low pH intolerance among other factors.

The presence of ectendo infection in some nurseaies may be due to high watering frequency and over fertilization which is known to change the balance in favour of these organisams.

In the light of observations made above it is apparent, that introduction of mycorrhiza in pine nurseries located outside the pine zone by use of soil inoculum has not yet been perfected. The success of pine trials in these areas appears to be mainly dependent on developing mycorrhizal association with symbiotic fungi present in the site.

Further research is, therefore, needed to perfect soil inoculation technique for introduction of mycorrhiza in nursery seedlings, work out the proportion of soil inoculum in the mixture, improving soil conditions by soil amendments like use of organic manure, compost, and chemicals, determining effects of various fungicidal treatments and other factors which may delay or impede development of mycorrhiza.

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The authors express sincers thanks to Shri R.L. Chowdhary, I.F.S.. Coordinator, Tropical Pine Research Centres, F.R.I. & Colleges, Dehra Dun for providing facilities for investigation and Shri Sujan Singh, Senior Research Officer, Disease Insects Survey Branch F.R.I. & Colleges for going through the manuscript and helpful suggestions.

SUMMARY

The paper reports the observations made on status of mycorrhiza in pine nurseries of dome areas of Orissa, Andhra Pardesh and Madhya Pradesh and grasslands of Tamil Nadu. Mycorrhizal infections are categorised into seven forms. Presence of mycorrhiza in each nursery is compared with the nursery practices followed. The mycorrhizal development in general was found erratic and inadequate in most cases probably due to insufficient quantity of mycorrhizal soil or high pH.

रोपणी पौधों में चीड़ कवकमूलता का अध्ययन

लेखक एच०एस० थापर व डी०पी० पालीवाल

सारांश

इस अभिपत्र में उड़ीसा, आंध्रप्रदेश और मध्यप्रदेश के कुछ क्षेत्रों में तथा तमिलनाडु के घास क्षेत्रों में बनाई हुई चीड़ रोपणियों में कवकमूलता स्थिति के अवलोकनों की सूचना दी गई है। कवकमूलता अंतः क्षेपणों को सात रूपों में वर्णित किया गया है। प्रत्येक रोपणी की कवकमूलता की तुलना उस रोपणी में उपयोग की गई रोपणी विधि से की गई है। कवकमूलता विकास समान्यतः अनियमी और अधिकांश मामलों में अपर्याप्त पाया गया जो ऐसा संभवतः कवकमूलता मृदा की अपर्याप्तता या उच्च पीएच के कारण है।

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EFFECTS OF PRESOWING STRATIFICATION OF SEED OF *PINUS CARIBAEA* VAR. *HONDURENSIS* ON GERMINATION

BY

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It has become a regular practice of this Department to obtain (purchase) Pine seed from abroad about one year in advance and keep it under cold storage to avoid last minute problems of import and receipt in time, of such seed from abroad (particularly from Central America), which will upset the entire nursery schedule and subsequent planting programmes.

Pinus caribaea var. *hondurensis* seed purchased from M/s. Seed Eexport, Lewald, Gautemala (Central America) during June 1979, was held in Cold Storage for over one year, sealed in double alkathene bags stippled and well sealed to exclude moisture. The temperature maintained in the Deep Freeze (Cold Storage) varied between 0°C–4°C. The seed had 8–10% moisture content.

Monthly germination tests of the stored seed were carried out on sample of seeds stored separately in small sealed packets right from June 1979. The seed as received from Gautemala, when last sown in June 1979 unstratified (straight), gave a germination of 47.8%. By January 1980, the germination fall down to 19.2%, and the same continued to fall further and by August 1980, it went down to 5.5% only. In order to test whether, due to prolonged storage of seed at low temperatures, dormancy has set in the seeds which is contributing to such low germination per cent observed when seeds are sown straight without stratification, stratification of seed was tried experimentally before sowing. The first batch of seed was stratified and sown in November, 1980.

Method of stratification adopted

A rectangular top open wooden box of 45×45×60 cm size with a number of 2–3 cm diam. holes at the bottom for adequate drainage of excess water, was used for the purpose. A 3 cm thick layer of Paddy husk was spread at the bottom of the box, over which Pine seed was spread but kept in loose white Muslin cloth bags. Four bags each containing between 250 gm to 500 gm of seed were so arranged over the Paddy husk layer, to form a 3 cm thick layer. The total quantity of seed used once did not exceed 2 kg. A 2–3 cm, thick layer of Paddy husk was again spread over the bags of seed, and about 2–3 kg of ice broken into small pieces was spread over the top layer of Paddy husk which was in turn covered over by another 5 cm thick Paddy husk. The outer most layer of Paddy husk was meant only for insulating ice from outside high temperatures and to prevent its melting too fast. The wooden box filled as above was kept inside a room raised on stones to facilitate free drainage of water from bottom. As the ice completely melted, it was replaced by a fresh layer of ice. It was, however, observed that generally the ice required replacement only every 24 hours. As the ice melted, the ice cool water trickled through the Paddy husk layer and through the seed, maintaining a temperature of slightly above 0°C. The Paddy husk layer between the seed bags and ice pieces, prevented ice coming in direct contact with the seed, and any consequent injury to seed. Treatment as above was continued for one week, after which the treated seed was sown directly in germination beds as per normal practise. Marked improvement in germination per cent and shortening of the period of completion of germination, as well as germination time was noticed in such treated (stratified) seed, as indicated below :

	Germination time (first germination noticed)	Period of completion of germination	Percentage of germination
1. Stratified seed	13–15 days	3 days	24
2. Unstratified seed	20 days	6–7 days	5.5

Experiments are being continued to find out the optimum period of stratification, to obtain the highest germination per cent of such seed stored in deep freeze for upto one year before actual use.

GIBBERELLINS IN FLOWERING AND NON-FLOWERING TREES OF *PINUS CARIBAEA*

BY

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Introduction

The physiological role of gibberellins (GAs) in various morphogenetic processes has been reviewed recently (Jones, 1973; Pharis and Kuo, 1977). Though flowering—a morphogenetic phenomenon in a few Pinaceae members is associated with high endogenous levels of non-polar GAs and lowered concentrations of the polar GAs (Kuo, 1973; Kamienska *et al.*, 1974), the induction of precocious flowering in this group of conifers has always been a difficult proposition. *Pinus caribaea* Morelet, a tropical pine recently introduced in India, has the juvenile phase extending upto 15–20 years To induce precocious flowering in this conifer through exogenous applications of GAs, guidance can be provided by studies in which the endogenous GAs of the flowering trees are analysed and compared with non-flowering trees.

Material and methods

Long shoots—equivalent to and potential female strobili from a 17 year old flowering and a 6 year old non-flowering tree of *Pinus caribaea* Morelet, were collected in early February, 1981, as this period coincides with the time of floral induction in this species. These long shoots were then extracted for GAs as described by Kamienska and Pharis (1975). The acidic, ethyl acetate soluble residue was purified by column chromatography on PVP (Glenn *et al.*, 1972). GAs in the sample were separated on a silica gel partition column eluted successively with 20%. 40% and 65% ethyl acetate in n-Hexane and two washings of 100% Ethyl acetate (Durley *et al.*, 1972). Each of the 48 silica gel column fractions (10 ml each) was assayed for GA activity using barley endosperm assay.

Results and discussion

Total acidic, ethyl acetate soluble GA activity in the long shoots of the flowering *Pinus caribaea* tree was 767.5 ng/kg. dry weight. On the other hand the total GA activity in the long shoots of the non-flowering tree was 521.5 ng/kg dry weight. The total GA activity was thus, 1.5 times higher in the long shoots of the flowering tree than in the long shoots of the non-flowering tree.

The data represented as a histogram in Fig. 1 clearly shows that the endogenous level of the non-polar GAs i.e. GA_9 and GA_5, as also of the polar GAs i.e. GA_3, GA_2, GA_8 and GA_{28} is higher in the long shoots of the flowering tree than in the long shoots of the non-flowering tree. GA_{4+7}, eluted in fraction 8–10, were only marginally more in the long shoots from the flowering tree than in the long shoots from the non-flowering tree. GA_{19+30}, slightly more polar than GA_3, were exclusive for the long shoots from the flowering tree. These were found to be totally lacking in the long shoots from the non-flowering trees. GA_{34} and GA_1, which are slightly less polar than GA_3, and the unknown GA-like substances (Fraction 42-43 and 45–46) were more in the long shoots from the non-flowering tree.

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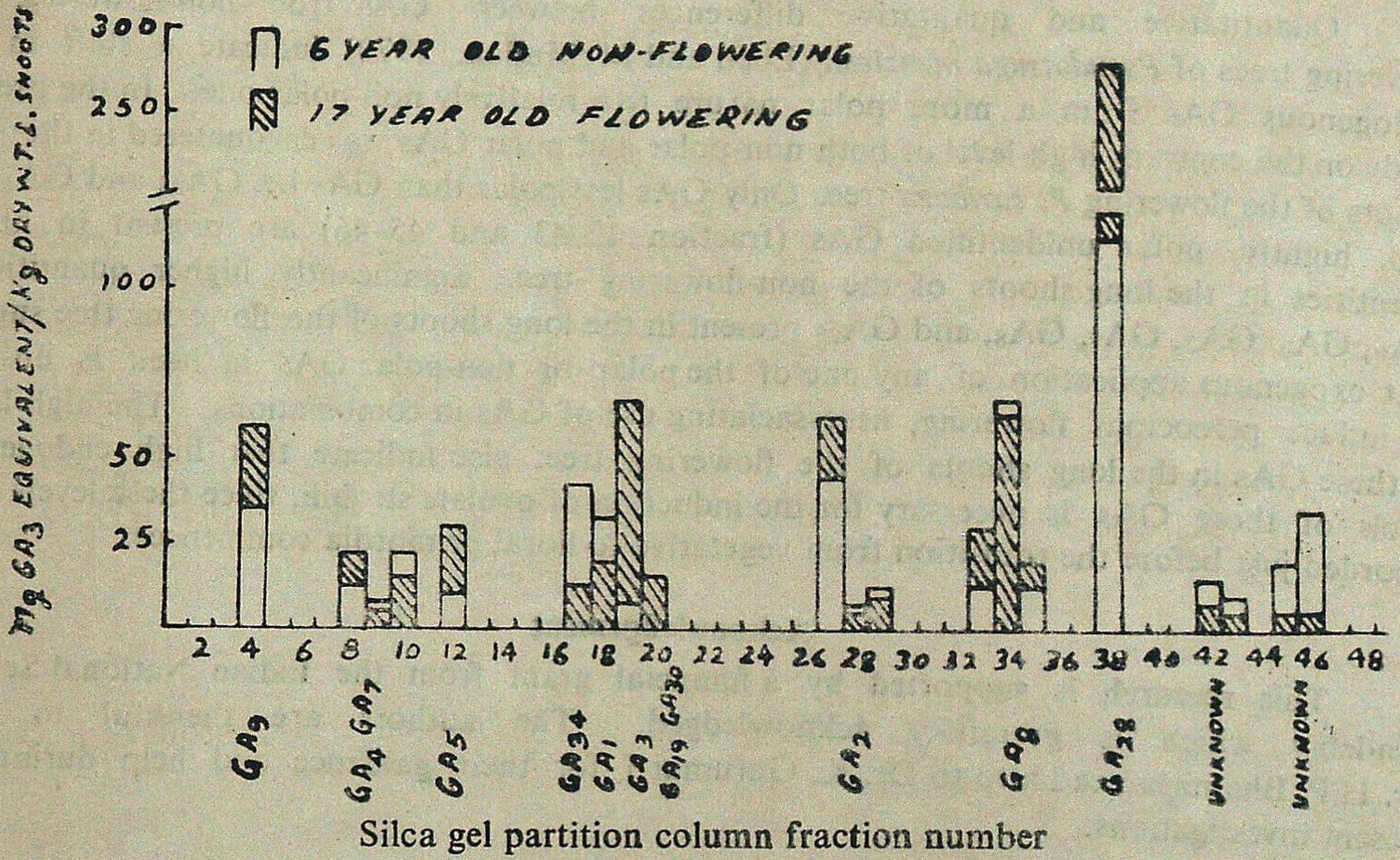
Fig. 1



Gibberellins present in the long shoots of the flowering and non-flowering *Pinus caribaea* trees. Bioassay data obtained from serial dilutions of fractions from silica gel partition column

Within the members of Pinaceae, promotion of flowering by GA_3 in Juvenile individuals has generally been unsuccessful. GA_3 promoted precocious flowering has been reported, however, in *Pinus taeda* (Ross and Greenwood, 1979), *Pinus mugo* (Shidei and Yoshikawa, 1963). Though GA_3 was found to be 9 times more in the long shoots of the flowering tree than in the long shoots of non-flowering one, however, in continuation of the present investigation, its exogenous application to juvenile *P. caribaea* plants under long day, short day and normal day conditions did not bring about precocious flowering, possibly due to other GAs being limiting. High endogenous GA_3 level is associated with ovulated strobili formation in *Cupressus arizonica* (Pharis *et al.*, 1969) and *Pinus banksiana* (Larson, 1961). Its high endogenous level in the long shoots of flowering *P. caribaea* tree possibly is a pointer towards the differentiation of ovulate strobili, since the long shoots are equivalent to and potential female cones. Of particular interest in the present investigation is the presence of GA_{19+30} in the long shoots from the flowering tree and its total absence in the long shoots of the non-flowering tree. As yet it remains to be emphetically elucidated whether GA_{19+30} is in any way associated with the differentiation of ovulated strobili in *P. caribaea*. It is postulated that in younger seedlings the endogenous concentration of total GAs is adequate for shoot elongation but well below the level necessary for strobili differentiation (Pharis and Morf, 1969). In the present study with *P. caribaea* total GA activity was 1.5 times higher in the long shoots of the flowering tree than in the long shoots of the non-flowering tree.

Quantitative and qualitative differences between GAs from non-flowering and flowering trees of *Pseudotsuga menziesii* (Ebell and McMullan, 1970) indicate a shift in the endogenous GAs from a more polar nature to a relatively non-polar one. In the present study on the contrary high level of both non-polar and polar GAs was encountered in the long shoots of the flowering *P. caribaea* tree. Only GAs less polar than GA_3 i.e. GA_{34} and GA_1 and two hightly polar unidentified GAs (fraction 42–43 and 45–46) are present in higher quantities in the long shoots of the non-flowering tree. Significantly, higher quantities of GA_9, GA_5, GA_3, GA_2, GA_8, and GA_{28} present in the long shoots of the flowering tree suggest that exogenous application of any one of the polar or non-polar GAs in itself is unlikely to induce precocious flowering, necessaciating use of GAs in combinations. The high levels of these GAs in the long shoots of the flowering tree, also indicate that high endogenous levels of these GAs is necessary for the induction of ovulate strobili, since these levels were recorded just before the transition from vegetative to floral primordia commences.

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SUMMARY

Long shoots—equivalent to and potential female strobili from a 17 year old flowering and 6 year old non-flowering trees of *Pinus caribaea* Morelet were extracted, isolated and identified for activity of various polar and non-polar GAs. It was found that total GA activity in long shoots of flowering tree was 1.5 times higher than the long shoots of non-flowering tree.

पाइनस *कैरिबिया* के पुष्पित और अपुष्पित रहने वाले वृक्षों में जिबेरेलिनों का प्रभाव

लेखक एस०के० रावल व डी०सी० अग्रवाल

सारांश

सत्रह वर्षीय पुष्पित होने वाले एक तथा अपुष्पित रह जाने वाले छह पाइनस *कैरिबिया* मोरलेट वृक्षों से लम्बे प्ररोह, जो स्त्री शंकु के बराबर और संभाविता वाले थे, निकाले और पृथक किए गए तथा विभिन्न ध्रुवीय और अध्रुवीय जिबेरेलिक अम्लों की सक्रियता उनपर जांची गईं। परिणामत: पाया गया कि अपुष्पित रह जाने वाले वृक्षों के लम्बे प्ररोहों के मुकाबले में पुष्पित वृक्षों के लम्बे प्ररोहों में जिबेरेलिक अम्ल की कुल सक्रियता 1.5 गुना अधिक है।

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AIR LAYERING IN *PINUS PATULA* SCHL. AND CHAM. AND *PINUS CARIBAEA* MORELET. VAR. *HONDURENSIS*

BY

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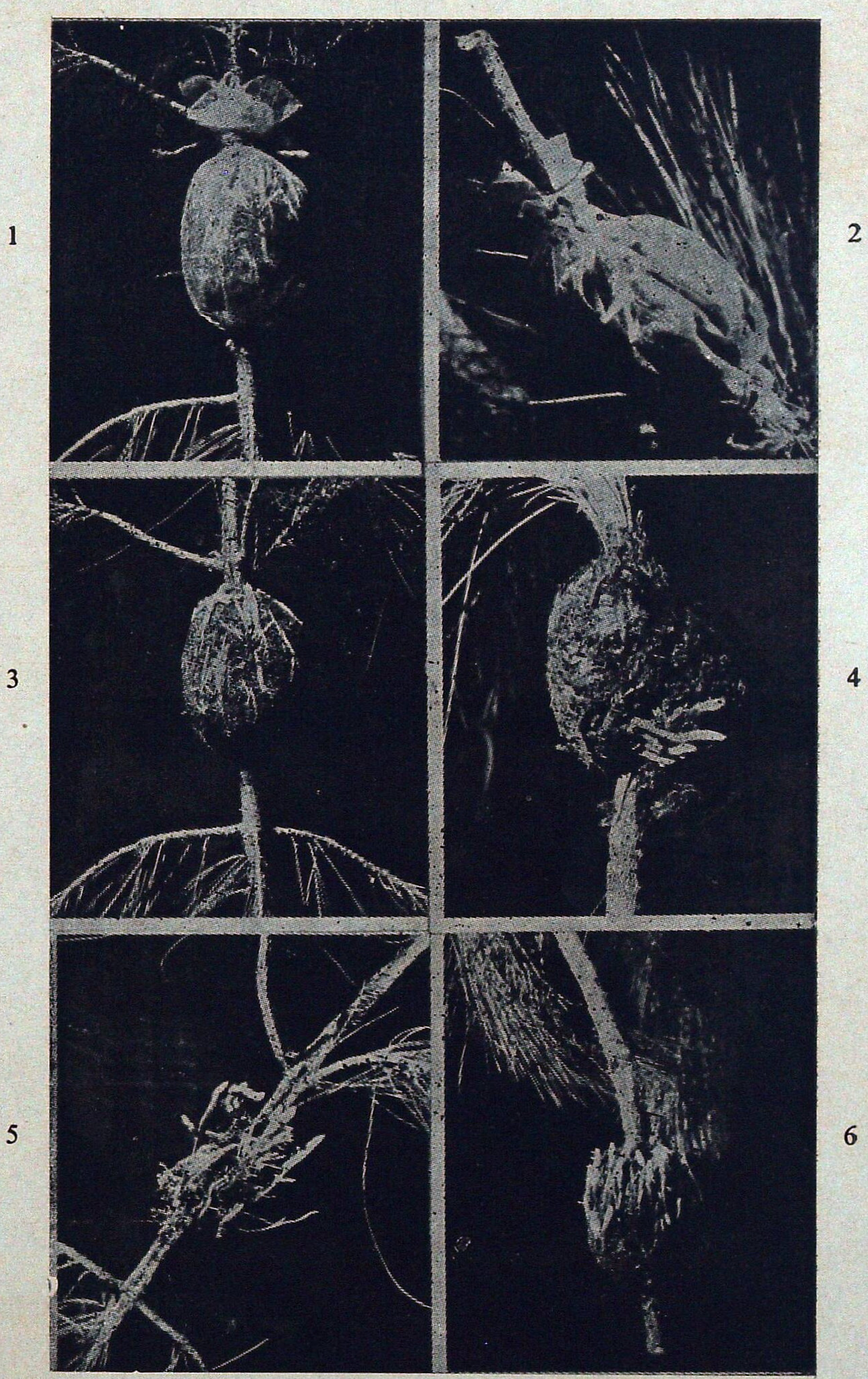
Introduction

In comparison with other forest trees, the genus *Pinus* has proved to be the most important and useful as raw materials for wood based industries the world over. Among tropical pines, *Pinus patula* and *P. caribaea* have been most successful as introduction in many countries. *P. patula* has been widely planted in its native country Mexico and also in South Africa, Rhodesia, Tanzania, Kenya, Uganda, Malawi, Malagassy etc. In India too this species has been widely planted in several states (Ghosh and Guhathakurta, 1973). *P. caribaea* commonly known as the caribbean pine is a native of central America, Mexico and some of the islands in the caribbean sea. This species received little attention until the last 30 years, but in the last decade has come to be one of the species considered most promising for tropical areas. Preliminary provenance tests indicate that the species is geographically variable and it is one of the first species being planted on a large scale with adequate provenance information. As an exotic in India it has shown great promise for its fast growth and suitability for planting in the lower altitudes. Because of their good prospects in wide scale plantations, it was thought essential to standardise the techniques of vegetative propagation for future use in genetic improvement programmes.

Vegetative propagation comprising of grafting, air layering and cuttings is of the greatest importance in forest tree improvement. It is a vital technique by which clonal seed orchards can be established by assembling the desired combinations of valuable inherent characteristics. It also enables a tree breeder to multiply quickly for further planting of desired tree species and maintain the parental genotype. Moreover, vegetatively propagated tree generally flower earlier than the seedlings and thus makes it possible to do controlled pollination work on trees less than 10 or 20 ft. tall. Also such trees can be planted in a convenient location instead of being scattered over a large area.

Air layering by which roots can be induced in a great variety of tree species has been reported in many pines e.g. in *Pinus elliottii* Engelm (Mergen, 1955), in *P. taeda* Linn. and *P. echinata* Mill. (Zak 1956), in *P. roxburghii* Sargent. (Chaudhri, 1962, Kedharnath and Dhaundiyal, 1963). Sporadic attempts have also been made of air layering in *P caribaea* (Kedharnath and Dhaundiyal, 1963) and in *P. patula* (Lahiri, 1981). However, the works of these authors are all preliminary. The present paper gives in detail the air layering studies carried out over a calendar year.



Figs. 1–2 : Rooting in *Pinus patula* and *P. caribaea* developed within the polythene sleeve.
Figs. 3–4 : Roots as seen after removing the polythene sleeve.
Figs. 5–6 : Roots as seen after removing the moss.

Materials and methods

For carrying out air layering studies in *Pinus patula* and *P. caribaea* var. *hondurensis*, small plantations of these two species aged 9 years growing at different areas of New Forest (Kaulagarh experimental plot) were selected. In each species, 10 air layers were made every month during a calendar year for finding out the best time for maximum rooting success. Two year old region of vigorously growing branches at different height of the trees were used for the purpose. The thickness of the branches were 2.0-2.5 cm, about 40-60 cm below the tip. Approximately 1.5 cm wide girdles were made with the help of a sharp knife by removing the bark. Root inducing hormone seradix B_3 was applied on the upper end of the girdles in the form of paste. *Sphagnum* moss which was first wetted in water and then squeezed of the excess water was placed around the girdles. The lump of the moist moss was then covered with polythene sleeves and tied firmly on both the ends so that moisture is retained inside. The air layers were checked periodically to see the formation of callus as well as initiation of roots without opening the polythene sleeves.

Results

Root initiation started after about 2 months in both the species (Figs. 1-2). Profuse rooting was found in the air layers made during the period June to August (Figs. 3-6). The maximum success achieved was 40 per cent in the month of August both in *P. patula* and *P. caribaea*. The detailed results are given in Table 1. Rooted air layers were severed with a sharp secateur from the main trees and later on planted individually in soil in pots. The air layers gradually established themselves well which will be transplanted in the field later on.

Table 1

Percentage of successful air layers in P. patula and P. caribaea var. *hondurensis*

Months	Percentage of success	
	P. patula	*P. caribaea* var. *hondurensis*
February	0	0
March	0	0
April	0	0
May	0	0
June	20	30
July	30	30
August	40	40
September	20	10
October	0	0
November	0	0
December	0	0
January	0	0

Discussion

From the present studies it seems that vegetative propagation of *P. patula* and *P. caribaea* var. *hondurensis* is possible with ease by air layering. Lackhan (1972) got best results in *P. caribaea* var. *hondurensis* by air layering than by grafting or cuttings. In the present investigation good success of rooting was achieved during the months of June to

August. However, the percentage of such success was not satisfactory. For effective use of vegetative propagation for large scale plantation or other purposes at least a success of 50-60 per cent is desirable. Lahiri (1981) also found only 30 per cent success in *P. patula* air layered in the month of July. However, Kedharnath and Dhaundiyal (1963) found 100 per cent success in *P. caribaea* in the month of June. But this result of 100 per cent success seems debatable. Morerover, the result was based on only 4 air layers which is also not correct. For a conclusive result at least 10 air layers are desirable. However, our work as well as the previous authors, work on air layering in *P. patula* and *P. caribaea* that are available in India suggests, that the best time for such experiments are the months of June to August. This observation is significant. The causes of our low success of only 40 per cent may be attributed to the damage caused by crows and monkeys. Because it was observed that some of the air layers were damaged before root initiation. If such biotic factors are controlled, it is hoped that the percentage of success would be increased. The studies would be continued for making fresh air layers in the favourable period.

Acknowledgements

The authors are grateful to Shri R.N. Kaul, I.F.S., Director, Forestry Research, Forest Research Institute & Colleges for going through the paper and suggesting modifications wherever necessary.

SUMMARY

Air layering in *P. patula* and *P. caribaea* var. *hondurensis* was successfully carried out under Dehra Dun conditions using two year old vigorously growing branches of trees. In both the species percentage of success was 40. The best time of air layeriug was the months of June to August.

पाइनस पैटुला श्ले० व चैम० तथा पाइनस कैरिबिया मोरनेट की दाब कलम लगाना

लेखक आर०एस० आर्य व एम०एस० हक

सारांश

वृक्ष की दो वर्षीय ओजस्विता से बढ़ रही शाखाएं उपयोग में लाकर देहरादून दशाओं में पाइनस पैटुला और पाइनस कैरिबिया विभेद होन्डोरेन्सिस में सफलतापूर्वक दाब कलम लगाई गई। दोनों जातियों में सफलता का प्रतिशत 40 रहा। दाब कलम लगाने का सबसे अच्छा समय जून से अगस्त रहा।

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INITIAL SPACING AND GROWTH OF *PINUS CARIBAEA*

BY

R.N. KAUL* AND K.K. SHARMA†

Introduction

Over the years Tropical Pines have shown promise in certain parts of India where plantations are being taken up. Initial spacing of trees has a major effect on volume production, both intermediate and final yields, the size of such material, increment, the form of the trees, timber quality and establishment costs. An experiment was, therefore, laid out in 1972 at the Forest Research Institute (F.R.I.), Dehra Dun to study the effect of different spacings on growth, development and yield of *Pinus caribaea.*

Description of the study

The study was conducted in the research block of F.R.I., Dehra Dun. The topography is almost flat. The soil is deep alluvium with good surface drainage. The texture of the soil is silty clay and the pH is 6.3. The mean annual rainfall is 2058 mm, mostly received from July to August. The mean maximum and the mean minimum temperatures are 35.6°C and 3.4°C respectively, while maximum and minimum daily temperatures are 42°C and –0.3°C respectively.

Experimental design

It consisted of a randomized block design having eight replications of four different treatments *viz.*, initial spacing of (S1) 2 m^2, (S2) 2.5 m^2, (S3) 3 m^2 and (S4) 3.5 m^2, making a total of 32 plots covering an area of approximately 0.72 ha, each plot being about 225 m^2.

The area was planted in August, 1972 with two year old *Pinus caribaea* var. *bahamensis* stock raised in polypots. The planting pits were 30 cm^2 cross section and 40 cm deep. Pits were treated with five per cent aldrex powder prior to planting to ward off termite attack. Planting stock of almost uniform size was planted in all the treatments.

In order to allow adequate buffering between plots, bordering plants were treated as guard rows.

Methods

Measurements—Observations on height and survival of the plants were recorded each year after planting while diameter at breast height was measured during 1980 and 1981 when the plants were eight and nine years old respectively.

For estimation of tree height and total stem volume (m^3) the following equations have been adopted (Singh and Mittal, 1982; Singh *et al.*, 1982).

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$$TV^{*}\ Sb = 0.40279\ D^2H + 0.03684/[2 \cosh 4.2\ (0 - D^2H)] - 0.01837$$

$TV^{*}\ Sb$ = total tree volume over bark down to 5 cm diameter limit.

Analysis—From the data thus collected, various crop parameters like crop diameter (mean), plot volume, plot basal area, survival per cent and crop height were computed for 1980 and 1981 measurements and analysed by analysis of variance (Table 5).

The data was also anlaysed by multiple regression method (Bella & Franceschi, 1980). In addition to spacing, growing ratio [growing space per tree (square spacing) divided by spacing^2] i.e. a measure of growing space to explain growth variation on account of mortality has been introduced as an independent variable in the regression (Table 5).

Results and discussion

Survival—The survival per cent of trees under different spacing treatments at the end of nine years is given in Table 1.

Table 1

Survival per cent as affected by different spacings

Spacing	No. of seedlings planted	No. of survival	Mortality	Survival (%)
2.0 m^2	512	418	94	81.5
2.5 m^2	288	223	65	77.4
3.0 m^2	200	147	53	73.5
3.5 m^2	128	95	33	74.2

Compared to wider spacings the survival per cent was higher in closer spacings which is ascribed to initial higher number of plants. However, increasing mortality of trees from wide to close spacings is apparent which lends support to the observations of other researchers (Whitmore and Liegel, 1980). Since mortality occurred soon after planting it is obviously not competition—induced.

Height growth—There is no marked difference in mean height of trees under different spacing treatments (Table 2). However, the general trend has been for wider spacing to produce taller trees.

Table 2

Mean height (m) as affected by spacing at nine years of age

Spacing	Mean height (m)
2.0 m^2	10.85
2.5 m^2	10.91
3.0 m^2	10.63
3.5 m^2	11.03

The world literature offers conflicting views on how spacing influences height growth. The discrepancies may be due to various ways of expressing height growth in assessment reports or varying abilities of different species to survive under crowded growing conditions. The age at which growth assessments are made is also critical and can affect interpretations of the spacing and influence of height growth. Many early spacing studies were limited to close spacings usually no greater than 1.8 or 2.4 m (Whitmore and Liegel, 1980). At these spacings most species will have severe competition and reduced growth if left unthinned.

Diameter growth—The mean diameter at breast height at nine years recorded under different spacing treatments is given in Table 3.

Table 3

Mean diameter (cm) as affected by spacing at nine years of age

Spacing	Mean diameter at breast height (cm)
2.0 m²	13.5
2.5 m²	14.8
3.0 m²	15.4
3.5 m²	16.7

Mean diameter increased progressively from narrow to wider spacing. Diameter at 3.5 m² spacing was 23.7% higher than those at the 2 m² spacing.

Basal area and plot volume

Basal area—Basal area decreased as spacing increased. Highest and lowest basal areas per plot were 0.774 m² and 0.269 m² at a spacing of 2.0 m² and 3.5 m² respectively (Table 4).

Table 4

Mean plot basal area (m²) as affected by spacing at nine years of age

Spacing	Plot basal area (m²)
2.0 m²	0.774
2.5 m²	0.496
3.0 m²	0.362
3.5 m²	0.269

Plot volume—The analysis of variance for 1980 and 1981 measurements are given in Table 5.

Table 5

Analysis of variance of volume per plot values $(m^3/plot)$

Source	D.F.	S.S.	M.S.S.	F observed
		(for 1980)		
Treatments	3	22.527688	7.509229	38.217***
Error	28	5.501655	0.196488	
Total	31	28.029343		
Treatments	2 m^2	2.5 m^2	3 m^2	3.5 m^2
Mean	(3.259)	(2.043)	(1.384)	(1.070)
		(for 1981)		
Treatments	3	33.027686	11.009228	38.542***
Error	28	7.997907	0.285640	
Total	31	41.025593		
Treatments	2 m^2	2.5 m^2	3 m^2	3.5 m^2
Mean	(4.175)	(2.676)	(1.946)	(1.497)

***Significant at 0.1% level of probability.

It is seen that plot volumes at 2 m^2 spacing is highly significant (0.01 per cent level). There is, however, no difference between plot volume under 3 m^2 and 3.5 m^2 spacing treatments. Similar trend is observed in respect of the measurements carried out in 1981.

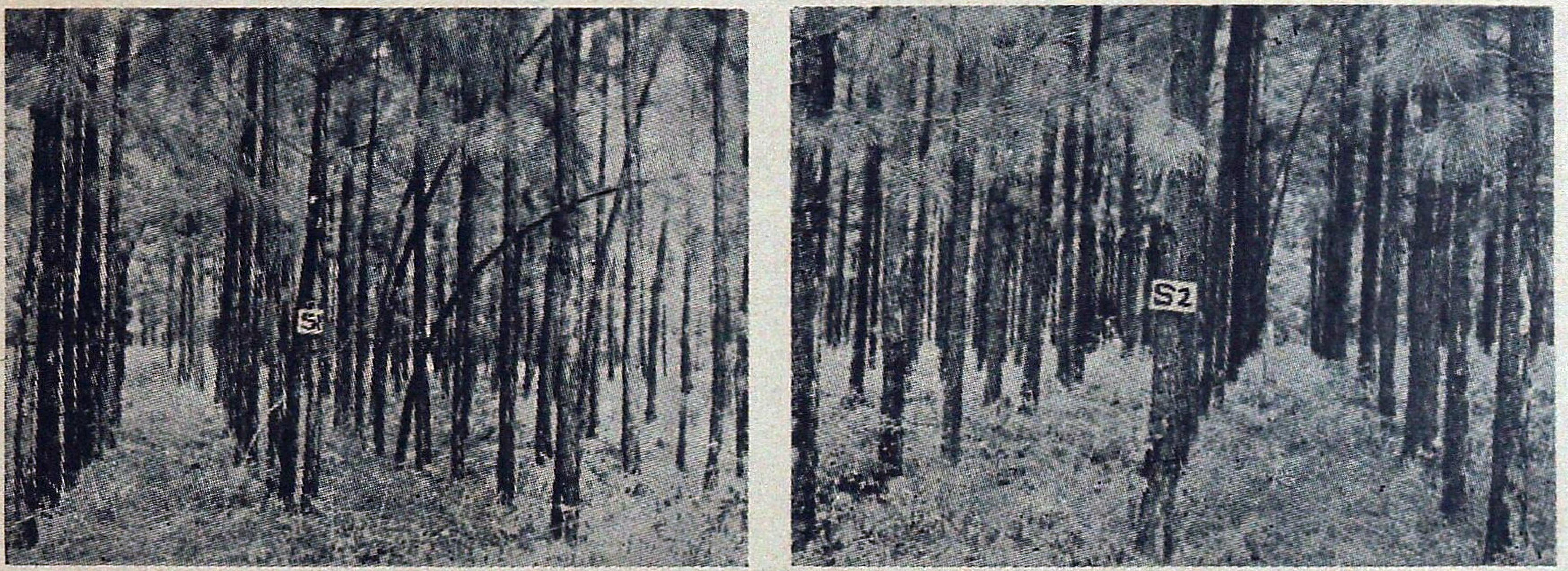
The mean plot volume values under different spacing treatments are set out in Table 6.

Table 6

Mean plot volume (m^2) *under different spacing treatments*

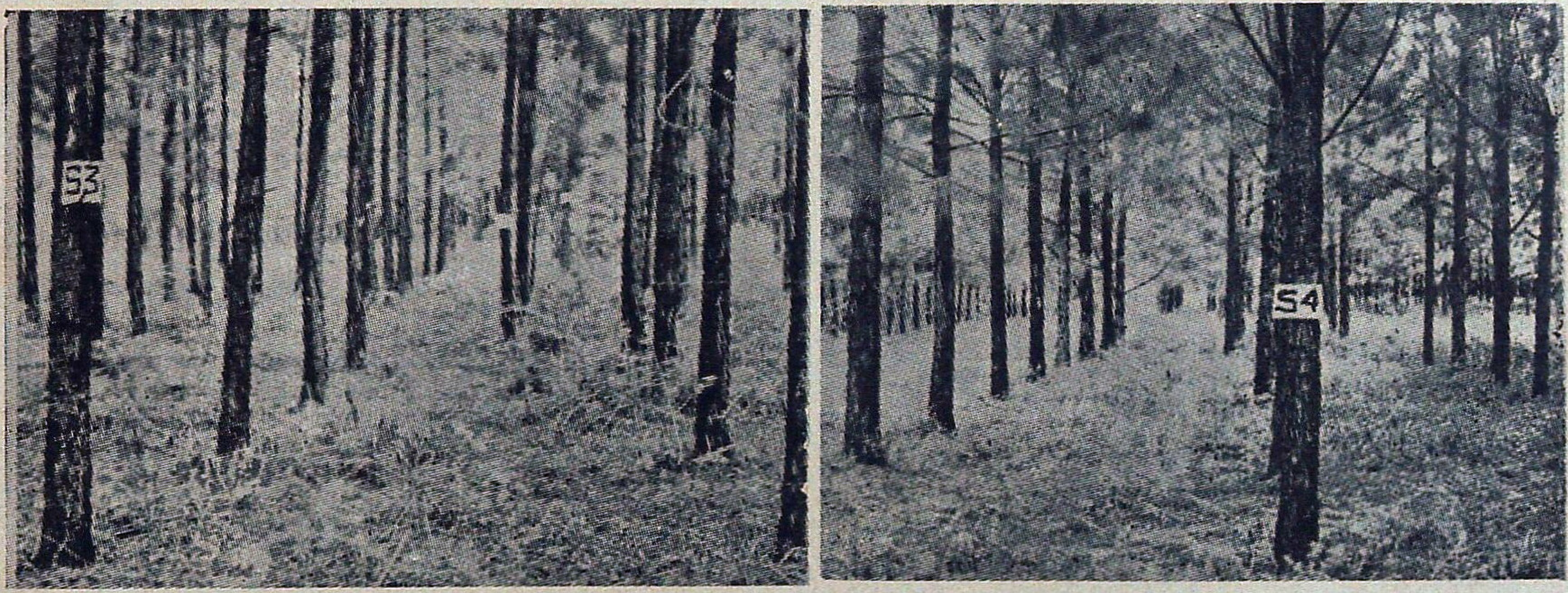
Spacing	Mean plot volume	
	1980	1981
2.0×2.0 m	3.259	4.175
2.5×2.5 m	2.044	2.676
3.0×3.0 m	1.384	1.946
3.5×3.5 m	1.070	1.497

The regression of volume increment over spacing, growth ratio and volume (before growing period) (Table 7) reveal that growth of *Pinus caribaea* is influenced by spacings as well as mortality in the initial years of growth and in subsequent years. The increment put on depends on the built up volume in the past years.



(a) 2 m^2

(b) 2.5 m^2



(c) 3 m^2

(d) 3.5 m^2

Fig. 1 (a to d) : *Pinus caribaea* var. *bahamensis* (nine-year-old) plots showing tree growth under different spacings.

Table 7

Regression of volume increment over spacing, growing space ratio and volume (before growing period)

Dependent variable	Independent variables x_1=spacing (m); $x_2=x_1^2$; x_3=growing space ratio*; $x_4=x_3^2$; x_5=volume before growing period; $x_6=x_5^2$ Regression co-efficients+							Multiple Regression co-efficient R	No. of observations N
	a	b_1	b_2	b_3	b_4	b_5	b_6		
M.A.I. at 8 years	71.41069	–33.84708	5.03534	–5.44573				.928	32
C.A.I. between 8th and 9th year of age.	3.05558					.54428	–.00171	.774	32

*Growing space ratio has been taken equal to 'growing space per tree (square spacing) divided by the (spacing)^2.

+All regression coefficients are significant at .01 level.

Using these growth regressions (Table 7), an estimate of fully stock (without mortality) stand volume and increments for different spacings were worked out and are given in Table 8.

Table 8

Volume (m^3/ha) and mean annual increment (M.A.I.) for different spacing treatments

Spacing (m)	For fully stocked stands (Volume m^3/ha)			
	At 8 years		At 9 years	
	Volume	M.A.I.	Volume	M.A.I.
2.0 × 2.0	147.296	18.412	193.421	21.491
2.5 × 2.5	102.544	12.818	143.431	15.937
3.0 × 3.0	77.936	9.742	113.024	12.558
3.5 × 3.5	73.464	9.183	107.276	11.920

It is seen that in closest spacings (*viz.*, 2 m^2) mean annual increment is highest and it continued to exhibit an appreciable increasing trend in subsequent measurement.

Conclusions

The main conclusions to be drawn from this experiment at this stage are as follows :

(1) The volume production per ha was markedly influenced by stocking. In the closest spacing, the mean annual increment at nine years was highest which was 21.491 m^3 per ha as against 11.920 m^3 per ha in the widest spacing *viz.*, 3.5 m^2. The top height attained in nine years was 10.9 m.

(2) It is evident from the data that *Pinus caribaea* does possess a potential of high yields and where tree size is not of much importance as in the case of pulpwood, it should be planted dense at a spacing of 2 m². The mean annual increment (M.A.I.) at an age of nine years still exhibited a rising trend and the age of harvest (rotation) will therefore depend on the culmination of M.A.I.

(3) The observation of the plots (Fig. 1) indicate unhealthy development of trees in plots with closer spacing and a big population tends to become lanky. Under these circumstances it is very likely that in the years to come the growth in plots with closer spacing may fall whereas under wider spacing the crop may continue to be healthier. From the trend of data collected so far it seems probable that the best spacing might lie between 2 m² to 2.5 m². Conclusive evidence about the optimum spacing could, however, be indicated only after this experiment progresses for some more years.

SUMMARY

The paper presents the results of spacing trials on *Pinus caribaea* var. *bahamensis*. The growth data at 8–9 years of age indicate that *P. caribaea* does possess a potential of high yields and where tree size is not of much importance as in the case of pulpwood, it should be planted dense i.e. at a spacing of 2 m². However, from the observation of the plots indicate unhealthy (lanky trees) under closer spacings. It is, therefore, likely that in the years to come the growth in plots with closer spacing may fall whereas under wider spacing the crop may continue to be healthier. It is probable that the best spacing might lie between 2 m² and 2.5 m². This could only be concluded after the experiment progresses for some more years.

पाइनस *कैरिबिया* में प्रारम्भिक अंतरालन और बढ़वार

लेखक आर०एन० कौल व कृष्ण कुमार शर्मा

सारांश

इस अभिपत्र में पाइनस *कैरिबिया* विभेद *बहामेंसिस* पर किए गए अंतराल परीक्षणों के परिणाम प्रस्तुत किए गए हैं। 8-9 वर्ष तक हुई बढ़वार के आकड़ों से दिखाई देता है कि *पा० कैरिबिया* में अधिक प्राप्ति देने की संभावनाएं हैं और जहां वृक्ष का आकार अधिक महत्व वाली बात नहीं जैसे लुगदी काष्ठ में वहां इसे घना अर्थात 2 मीटर वर्ग अंतराल पर लगाना चाहिए। तथापि, भूखण्डों के प्रेक्षणों से पता चलता है कि सन्निकट अंतराल देने पर अस्वस्थ (पतले) वृक्ष हुए। अत: इस बात की संभावना है कि आगामी वर्षों में सन्निकट अंतराल वावे भूखण्डों में वृद्धि घट जाए जबकि चौड़े अन्तरालनों में सस्य स्वस्थतर बना रहे। यह भी हो सकता है कि सर्वोत्तम अन्तरालन 2 मी० वर्ग और 2.5 मी० वर्ग के बीच में कहीं आए। इसका निष्कर्ष यह संपरीक्षण कुछ वर्षों तक और चलाते रहने के बाद ही दिया जा सकता है।

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PROVISIONAL VOLUME TABLES FOR TWO EXOTIC PINES (SPECIES *PINUS CARIBAEA* AND *PINUS PATULA*)

BY

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Introduction

To augment the meagre resource of long fibred pulping material in the country, the researchers led to the introduction of exotic conifers. The choice fell on tropical conifers because of their adaptability to considerable climatic and edaphic variations, less exacting nature both with regards to soil moisture and soil fertility requirements than hardwood components in the same general environment and above all its high rate of growth. Tropical pines have been tried so far in states of Himachal Pradesh, Uttar Pradesh, West Bengal, Orissa, Madhya Pradesh, Andhra Pradesh, Tamil Nadu and Kerala in varying proportions. *Pinus patula* and *Pinus caribaea* have shown success but the performances are not uniform. There has been problem in evaluating stand volume due to paucity of felled sample trees for volume measurements. And unless stand volume is known, it is difficult to judge productive potential of the species. In absence of sample trees, an estimate of stand volume can be had by use of 'volume tables'.

Thus an attempt has been made to prepare 'Provisional volume tables for *Pinus caribaea* and *Pinus patula*'. It is provisional because these tables are based on inadequate number of sample trees and secondly these do not cover wide range of distribution.

Data

Sample tree data of *Pinus caribaea* was collected from Barhampur (Orissa), Mandla (M.P.) and F.R.I. Estate, Dehra Dun (U.P.). In all there are 60 observations, out of which standing volume of 17 trees was measured with the help of Barr and Stroud Dendrometer in F.R.I. *Pinus caribaea* tree develop more pronounced branches as compared to *Pinus patula*. Wherever possible, branch volume in less inclined branches, was thus also measured in standing trees to make the volume figures more realistic. The following gives data range of parameters used in regression for *Pinus caribaea*.

Parameters	Mean value	Standard deviation	Unit	Denoted in the text by
Height	11.23	4.89	m	H
Diameter at breast height	.146	.092	m	D
Total volume (over bark upto 5 cm diameter limit)	.1945	.3409	m^3	TV_{sb}*

From the above it would be observed that trees are small sized.

All sample tree data in respect of *Pinus patula* was collected in F.R.I. Estate, Dehra Dun and standing trees were measured with the help of Barr and Stroud Dendrometer. In all there were 110 sample trees and as branches were slender, the measurement of no branchwood volume was attempted. The following was data range of parameters used in regeression for *Pinus patula.*

Parameters	Mean value	Standard deviation	Unit	Denoted in the text by
Heigt	12.49	2.32	m	H
Diameter at breast height	.166	.049	m	D
Stem volume (over bark upto 5 cm diameter limit)	.1498	.1122	m^3	TV_s*

Sample trees were generally small sized.

Analysis

The volume regressions developed were as under—

Pinus caribaea

$TV_{sb}^* = .40279\ D^2H + .03684/2\ \text{Cosh}\ 4.2\ (0 - D^2H) - .01837$

(t—value for regression coefficients) 38.031 .803

Multiple correlation coefficient R = .993

No. of observations N = 60

Pinus patula

$TV_s = .34489\ D^2H - .02487/2\ \text{Cosh}\ 8.3\ (0 - D^2H) + .01424$

(t—value for regression coefficients) 48.027 1.411

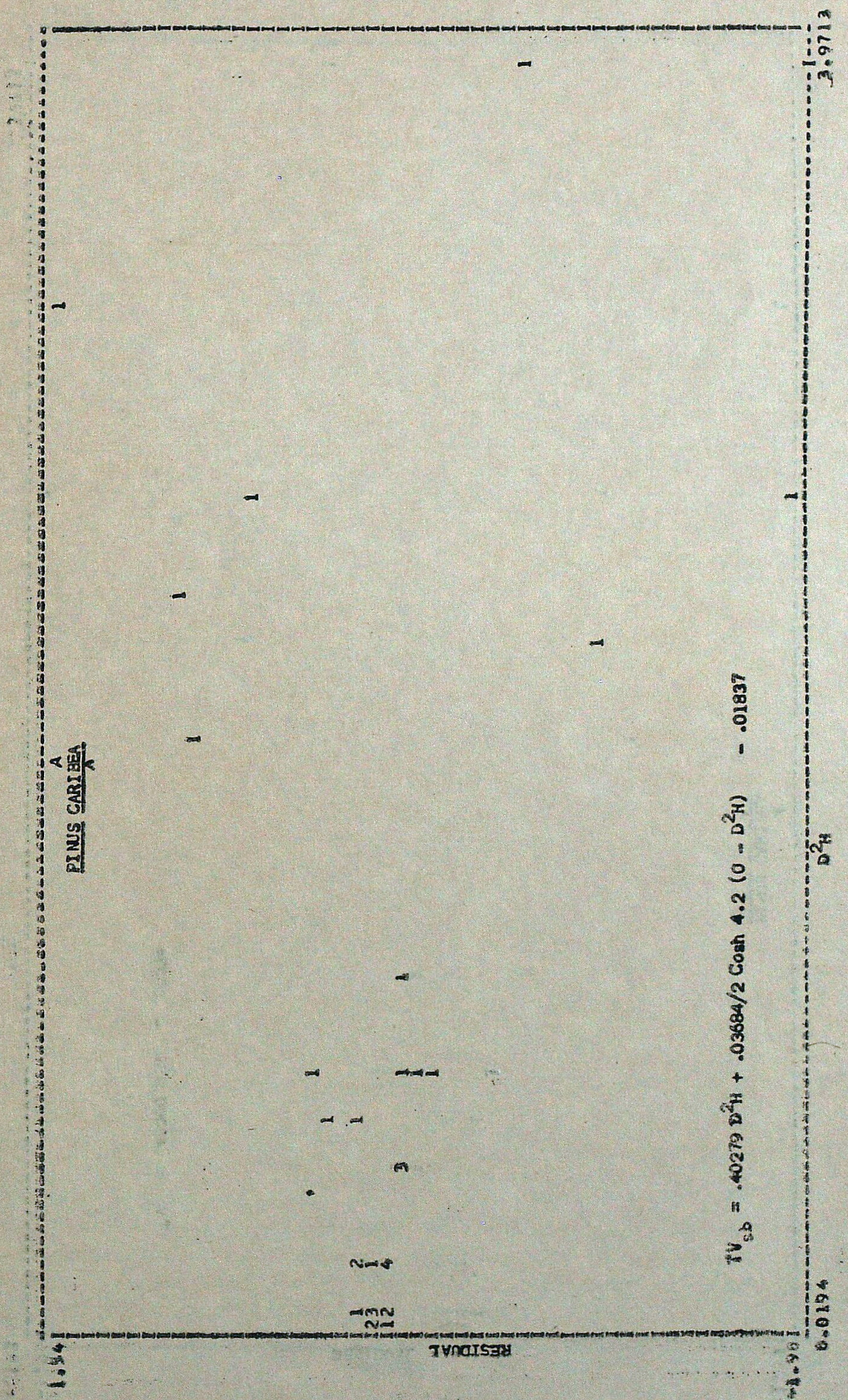
Multiple correlation coefficient R = .987

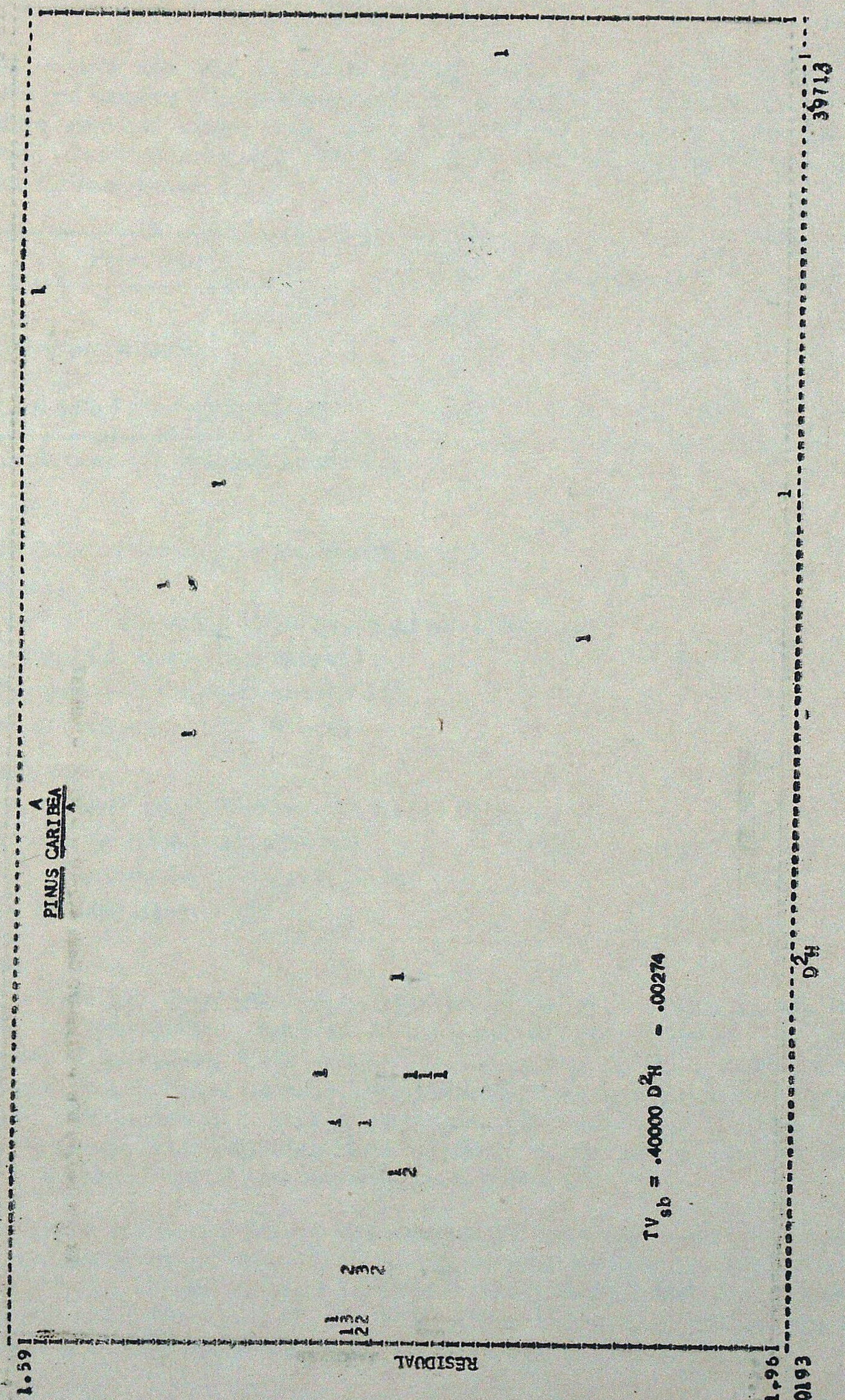
No. of observations = 110

Discussion

It will be seen from above that regression coefficients of 'Cosh function' in both regressions are not significant even at .05 level, but still their retention is desirable. The purpose of introducing 'Cosh function' in regression is to effect uniformity in the destribution of 'Residual' (tree volume-estimated volume) in lower range of data, a region were simple D^2H regression is weak in prediction. The introduction of 'Cosh function' has made the distribution of residuals uniform as revealed by the graphs attached. On the ordinate is "Residuals" and on Abscissa the values of D^2H in m^3.

The volume tables generated are also attached for ready use. Volume measurement overbark and underbark in respect of *Pinus caribaea* were recorded for felled trees. The range of such trees was from 5 to 15 cm diameter at breast height. Bark per cent for this range varied between 25.6 to 33.5%, the smaller trees having more bark per cent, which indicate that *Pinus caribaea* has a rather high bark percentage.


PINUS CARIBEA
$TV_{sb} = .40279\ D^2H + .03684/2\ \mathrm{Cosh}\ 4.2\ (0 - D^2H) - .01837$
RESIDUAL
1.54
-1.90
D^2H
0.0194
3.9713


PINUS CARIBEA
TV_{sb} = .40000 D^2H - .00274
RESIDUAL
D^2H
1.59
-1.96
.0193
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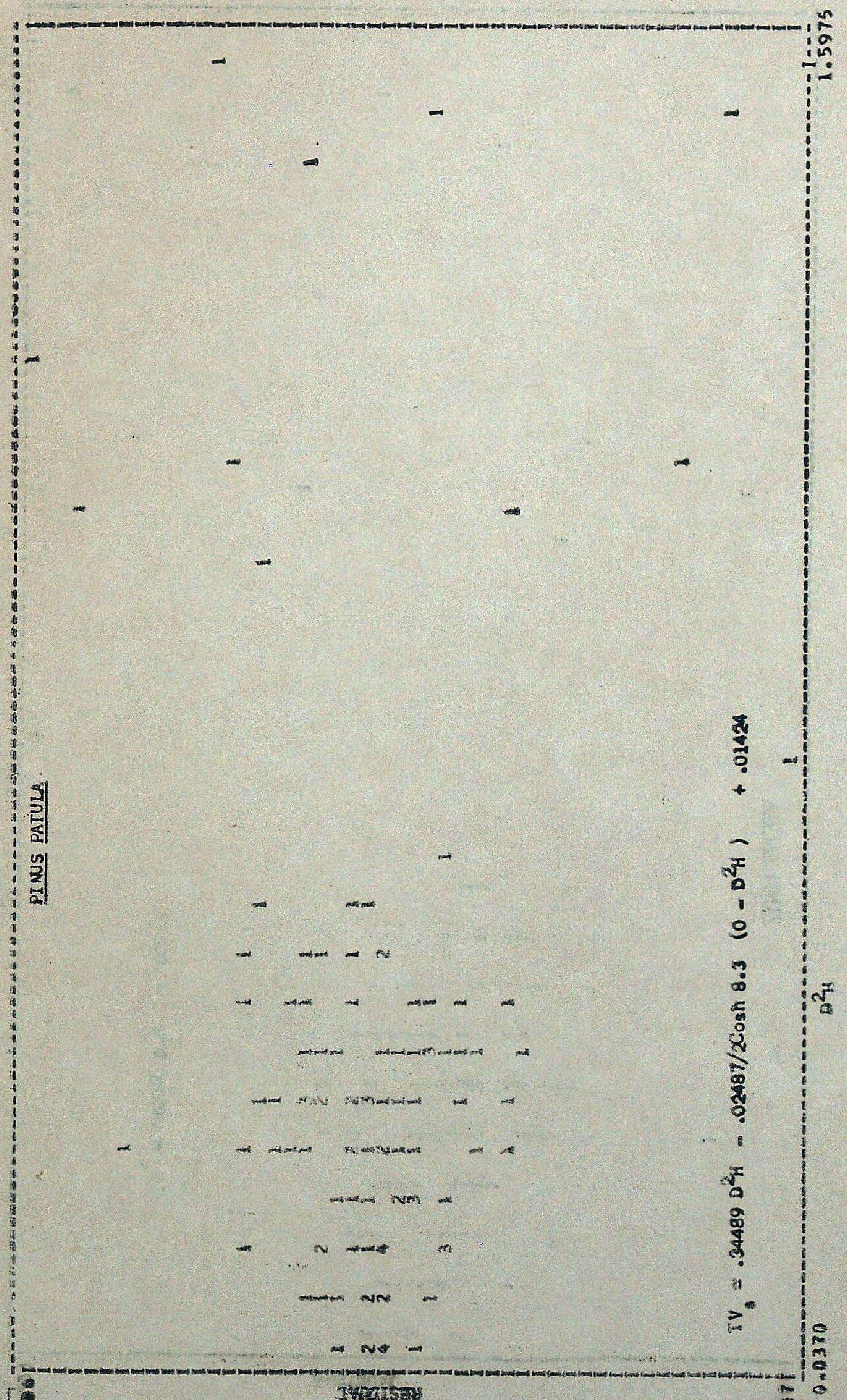
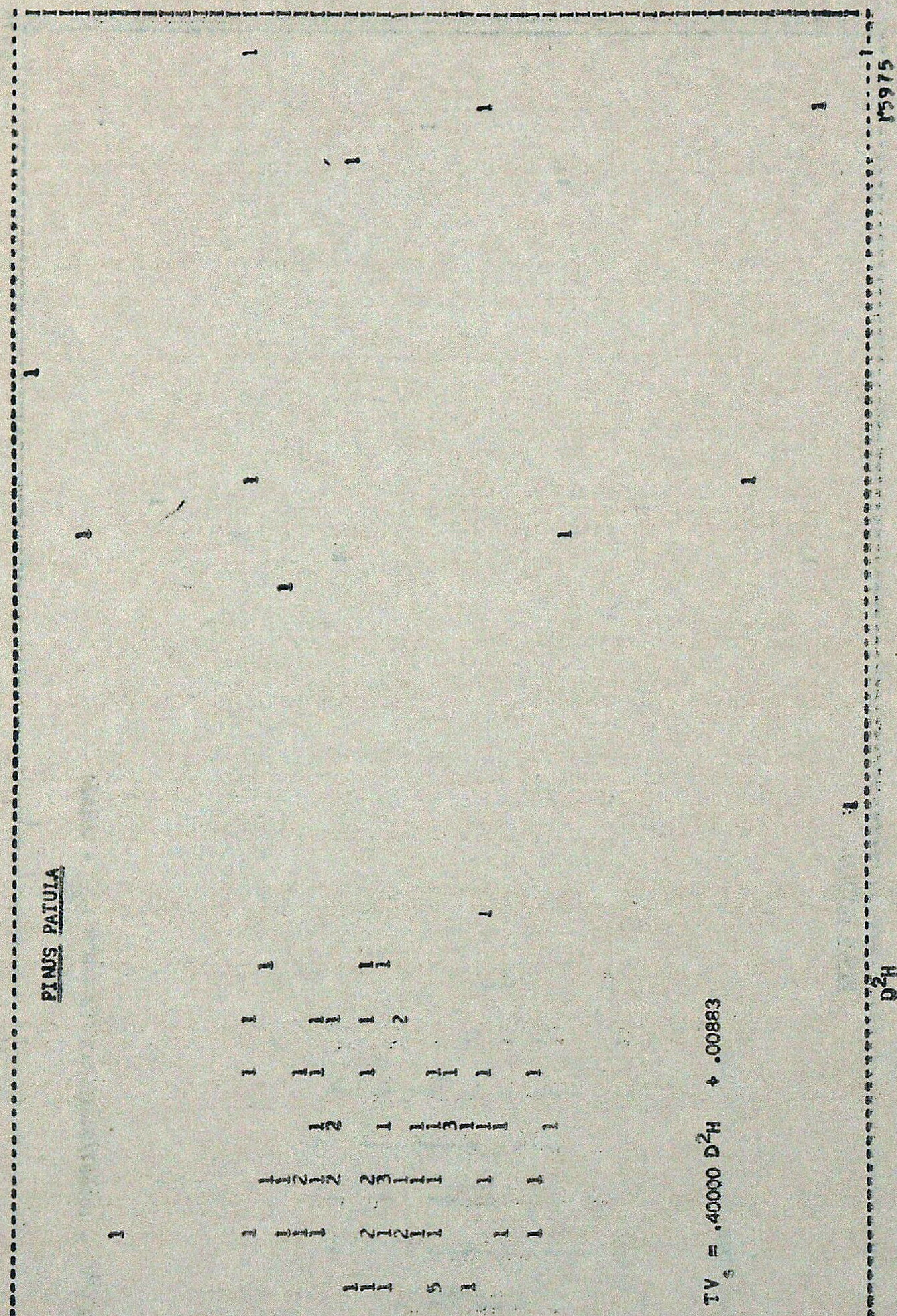

PINUS PATULA
TV_s = .34489 D²H - .02487/2Cosh 8.3 (0 - D²H) + .01424
D²H
0.0370
1.5975
RESIDUAL
0.06
-0.07


PINUS PATULA
TV$_s$ = .40000 D^{2}H + .00883
D^{2}H
RESIDUAL
0.06
-0.07
.0370
15975

(Total stem volume TV_s* in m^3)

PINUS PATULA

Numbers	5	6	7	8	9	10	11	12	13	14
5	0.006	0.007	0.008	0.009	0.010	0.011	0.012	0.013	0.013	0.014
	0.008	0.009	0.011	0.012	0.013	0.015	0.016	0.017	0.019	0.020
	0.011	0.012	0.014	0.016	0.018	0.020	0.022	0.023	0.025	0.027
	0.013	0.016	0.018	0.021	0.023	0.025	0.028	0.030	0.033	0.035
	0.016	0.020	0.023	0.026	0.029	0.032	0.035	0.039	0.042	0.045
10	0.020	0.024	0.028	0.032	0.036	0.040	0.044	0.048	0.051	0.055
	0.024	0.029	0.034	0.038	0.043	0.048	0.053	0.057	0.062	0.067
	0.029	0.034	0.040	0.046	0.051	0.057	0.063	0.068	0.074	0.079
	0.033	0.040	0.047	0.054	0.060	0.067	0.073	0.080	0.086	0.092
	0.039	0.047	0.054	0.062	0.070	0.077	0.085	0.092	0.099	0.105
15	0.045	0.053	0.062	0.071	0.080	0.088	0.096	0.105	0.113	0.121
	0.051	0.061	0.071	0.080	0.090	0.100	0.109	0.118	0.127	0.137
	0.057	0.068	0.080	0.090	0.101	0.112	0.122	0.132	0.143	0.153
	0.064	0.077	0.089	0.101	0.113	0.124	0.136	0.147	0.159	0.173
	0.071	0.085	0.098	0.112	0.125	0.138	0.150	0.163	0.176	0.183
20	0.079	0.094	0.108	0.123	0.137	0.151	0.165	0.179	0.193	0.207
	0.086	0.103	0.119	0.135	0.150	0.166	0.181	0.196	0.212	0.227
	0.094	0.112	0.130	0.147	0.164	0.181	0.198	0.214	0.231	0.248
	0.103	0.122	0.141	0.159	0.178	0.196	0.215	0.233	0.251	0.270
	0.111	0.132	0.152	0.173	0.193	0.213	0.233	0.253	0.272	0.292
25	0.120	0.142	0.164	0.186	0.208	0.230	0.251	0.273	0.294	0.316
	0.129	0.153	0.177	0.200	0.224	0.247	0.271	0.294	0.317	0.341
	0.139	0.164	0.190	0.215	0.240	0.266	0.291	0.316	0.341	0.365
	0.148	0.176	0.203	0.230	0.258	0.285	0.312	0.339	0.366	0.393
	0.159	0.188	0.217	0.246	0.275	0.304	0.333	0.362	0.391	0.420
30	0.169	0.200	0.231	0.262	0.294	0.325	0.356	0.387	0.418	0.449
	0.179	0.213	0.246	0.279	0.313	0.346	0.379	0.412	0.445	0.478
	0.190	0.226	0.261	0.297	0.332	0.367	0.403	0.438	0.473	0.509
	0.202	0.239	0.277	0.315	0.352	0.390	0.427	0.465	0.503	0.540
	0.213	0.253	0.293	0.333	0.373	0.413	0.453	0.493	0.533	0.572
35	0.225	0.268	0.310	0.352	0.394	0.437	0.479	0.521	0.563	0.606
	0.238	0.282	0.327	0.372	0.417	0.461	0.505	0.551	0.595	0.640
	0.250	0.298	0.345	0.392	0.439	0.486	0.534	0.581	0.628	0.675
	0.263	0.313	0.363	0.413	0.462	0.512	0.562	0.512	0.662	0.711
	0.276	0.329	0.381	0.434	0.486	0.539	0.591	0.644	0.696	0.749
40	0.290	0.345	0.401	0.456	0.511	0.566	0.621	0.676	0.732	0.787

	15	16	17	18	19	20	21	22	23	24
5	0.015	0.016	0.017	0.018	0.019	0.020	0.021	0.022	0.023	0.024
	0.021	0.023	0.024	0.025	0.027	0.028	0.030	0.031	0.032	0.034
	0.029	0.031	0.033	0.034	0.036	0.038	0.040	0.042	0.044	0.045
	0.037	0.040	0.042	0.044	0.047	0.049	0.052	0.054	0.056	0.059
	0.047	0.050	0.053	0.056	0.059	0.062	0.065	0.068	0.071	0.074
10	0.057	0.061	0.065	0.068	0.072	0.076	0.079	0.083	0.087	0.090
	0.069	0.073	0.078	0.082	0.086	0.091	0.095	0.100	0.104	0.109
	0.081	0.087	0.092	0.097	0.102	0.108	0.113	0.118	0.124	0.129
	0.095	0.101	0.107	0.114	0.120	0.126	0.132	0.139	0.145	0.151
	0.110	0.117	0.124	0.132	0.139	0.146	0.154	0.161	0.169	0.176
15	0.126	0.134	0.143	0.151	0.160	0.168	0.177	0.186	0.194	0.203
	0.143	0.153	0.163	0.172	0.182	0.192	0.202	0.212	0.222	0.232
	0.162	0.173	0.184	0.195	0.206	0.218	0.229	0.240	0.252	0.263
	0.182	0.195	0.207	0.220	0.232	0.245	0.258	0.271	0.283	0.296
	0.203	0.218	0.232	0.246	0.260	0.274	0.289	0.303	0.317	0.332
20	0.226	0.242	0.258	0.273	0.289	0.305	0.321	0.337	0.353	0.369
	0.250	0.268	0.285	0.303	0.320	0.338	0.355	0.373	0.391	0.408
	0.276	0.295	0.314	0.333	0.353	0.372	0.392	0.411	0.430	0.450
	0.303	0.324	0.345	0.366	0.387	0.408	0.429	0.451	0.472	0.493
	0.331	0.354	0.377	0.400	0.423	0.446	0.469	0.492	0.515	0.539
25	0.360	0.385	0.410	0.435	0.460	0.485	0.510	0.536	0.561	0.586
	0.391	0.418	0.445	0.472	0.499	0.526	0.554	0.581	0.608	0.635
	0.422	0.452	0.481	0.510	0.540	0.569	0.598	0.628	0.557	0.686
	0.456	0.487	0.519	0.550	0.582	0.613	0.645	0.676	0.708	0.740
	0.490	0.524	0.558	0.591	0.625	0.659	0.693	0.727	0.751	0.795
30	0.526	0.562	0.598	0.634	0.670	0.707	0.743	0.779	0.815	0.852
	0.562	0.601	0.640	0.678	0.717	0.756	0.795	0.833	0.872	0.911
	0.600	0.642	0.683	0.724	0.765	0.807	0.848	0.889	0.930	0.972
	0.640	0.683	0.727	0.771	0.815	0.859	0.903	0.947	0.990	1.034
	0.680	0.727	0.773	0.820	0.866	0.913	0.959	1.006	1.053	1.099
35	0.722	0.771	0.820	0.870	0.919	0.968	1.018	1.067	1.116	1.166
	0.765	0.817	0.869	0.921	0.973	1.026	1.078	1.130	1.182	1.234
	0.809	0.864	0.919	0.974	1.029	1.084	1.140	1.195	1.250	1.305
	0.854	0.912	0.970	1.029	1.087	1.145	1.203	1.261	1.319	1.378
	0.901	0.962	1.023	1.084	1.146	1.207	1.268	1.329	1.391	1.452
40	0.948	1.013	1.077	1.142	1.206	1.271	1.335	1.399	1.464	1.528

* Volume over bark

Column numbers—Tree height in metres

Row numbers—Diameter at breast height in cm.

PINUS CARIBAEA

(Total tree volume TV_{sb}* in m^3)

Numbers	5	6	7	8	9	10	11	12	13	14
5	0.005	0.006	0.007	0.008	0.009	0.010	0.011	0.012	0.013	0.014
	0.007	0.009	0.010	0.012	0.013	0.014	0.016	0.017	0.019	0.020
	0.010	0.012	0.014	0.016	0.018	0.019	0.021	0.023	0.025	0.027
	0.013	0.015	0.018	0.020	0.023	0.025	0.028	0.030	0.032	0.035
	0.016	0.019	0.022	0.025	0.029	0.032	0.035	0.038	0.041	0.044
10	0.020	0.024	0.027	0.031	0.035	0.039	0.043	0.046	0.050	0.054
	0.024	0.028	0.033	0.038	0.042	0.047	0.051	0.056	0.060	0.064
	0.028	0.034	0.039	0.044	0.050	0.055	0.060	0.066	0.071	0.076
	0.033	0.039	0.046	0.052	0.058	0.064	0.070	0.077	0.083	0.089
	0.038	0.045	0.053	0.060	0.067	0.074	0.081	0.088	0.096	0.103
15	0.043	0.052	0.060	0.068	0.077	0.085	0.093	0.101	0.109	0.118
	0.049	0.059	0.068	0.077	0.087	0.096	0.105	0.115	0.124	0.134
	0.055	0.066	0.076	0.087	0.098	0.108	0.119	0.129	0.140	0.151
	0.062	0.074	0.085	0.097	0.109	0.121	0.133	0.145	0.157	0.170
	0.068	0.082	0.095	0.108	0.121	0.135	0.148	0.162	0.176	0.190
20	0.076	0.090	0.105	0.120	0.134	0.149	0.165	0.180	0.195	0.211
	0.083	0.099	0.115	0.132	0.148	0.165	0.182	0.199	0.215	0.233
	0.091	0.109	0.126	0.145	0.163	0.181	0.200	0.219	0.238	0.257
	0.099	0.119	0.138	0.158	0.178	0.199	0.219	0.240	0.251	0.282
	0.108	0.129	0.151	0.172	0.195	0.217	0.239	0.262	0.285	0.308
25	0.117	0.140	0.164	0.187	0.212	0.236	0.261	0.285	0.310	0.335
	0.126	0.151	0.177	0.203	0.230	0.256	0.283	0.310	0.337	0.364
	0.136	0.164	0.191	0.220	0.248	0.277	0.306	0.335	0.364	0.393
	0.146	0.176	0.206	0.237	0.268	0.299	0.330	0.361	0.393	0.424
	0.157	0.189	0.222	0.255	0.288	0.321	0.355	0.389	0.422	0.456
30	0.168	0.203	0.238	0.273	0.309	0.345	0.381	0.417	0.453	0.489
	0.180	0.217	0.255	0.293	0.331	0.369	0.408	0.446	0.485	0.524
	0.192	0.232	0.272	0.313	0.354	0.395	0.436	0.477	0.518	0.559
	0.205	0.247	0.290	0.333	0.377	0.421	0.464	0.508	0.552	0.596
	0.218	0.263	0.309	0.355	0.401	0.448	0.494	0.540	0.587	0.634
35	0.231	0.279	0.328	0.377	0.426	0.475	0.525	0.574	0.623	0.672
	0.245	0.296	0.348	0.400	0.452	0.504	0.556	0.608	0.650	0.712
	0.259	0.314	0.368	0.423	0.478	0.533	0.588	0.643	0.698	0.754
	0.274	0.332	0.389	0.447	0.505	0.563	0.621	0.680	0.738	0.796
	0.289	0.350	0.411	0.472	0.533	0.594	0.655	0.717	0.778	0.839
40	0.305	0.369	0.433	0.497	0.562	0.626	0.691	0.755	0.819	0.884

	15	16	17	18	19	20	21	22	23	24
5	0.015	0.016	0.017	0.018	0.019	0.020	0.021	0.022	0.023	0.024
	0.022	0.023	0.024	0.026	0.027	0.029	0.030	0.031	0.033	0.034
	0.029	0.031	0.033	0.035	0.037	0.039	0.041	0.043	0.045	0.047
	0.038	0.041	0.043	0.046	0.048	0.051	0.053	0.056	0.058	0.061
	0.048	0.051	0.055	0.058	0.061	0.064	0.067	0.070	0.073	0.077
10	0.059	0.063	0.067	0.071	0.075	0.079	0.082	0.086	0.090	0.094
	0.072	0.076	0.081	0.085	0.090	0.094	0.099	0.103	0.108	0.112
	0.085	0.090	0.095	0.101	0.106	0.111	0.117	0.122	0.127	0.132
	0.099	0.105	0.111	0.117	0.123	0.129	0.135	0.141	0.147	0.153
	0.113	0.121	0.128	0.135	0.142	0.148	0.155	0.162	0.169	0.176
15	0.129	0.137	0.145	0.153	0.161	0.169	0.177	0.185	0.192	0.200
	0.146	0.155	0.164	0.173	0.182	0.190	0.199	0.208	0.217	0.226
	0.163	0.173	0.183	0.193	0.203	0.213	0.223	0.233	0.243	0.253
	0.181	0.193	0.204	0.215	0.226	0.238	0.249	0.260	0.271	0.282
	0.201	0.213	0.226	0.238	0.251	0.263	0.276	0.288	0.301	0.313
20	0.221	0.235	0.249	0.262	0.276	0.290	0.304	0.318	0.332	0.345
	0.242	0.258	0.273	0.288	0.303	0.318	0.334	0.349	0.364	0.379
	0.265	0.281	0.298	0.315	0.331	0.348	0.365	0.381	0.398	0.415
	0.288	0.306	0.324	0.343	0.361	0.379	0.397	0.416	0.434	0.452
	0.312	0.332	0.352	0.372	0.392	0.412	0.431	0.451	0.471	0.491
25	0.338	0.359	0.381	0.402	0.424	0.445	0.467	0.488	0.510	0.532
	0.364	0.387	0.411	0.434	0.457	0.481	0.504	0.527	0.550	0.574
	0.391	0.417	0.442	0.467	0.492	0.517	0.542	0.567	0.593	0.613
	0.420	0.447	0.474	0.501	0.528	0.555	0.582	0.609	0.636	0.663
	0.449	0.478	0.507	0.536	0.565	0.594	0.623	0.552	0.681	0.710
30	0.480	0.511	0.542	0.573	0.604	0.635	0.666	0.697	0.728	0.759
	0.511	0.545	0.578	0.611	0.644	0.677	0.710	0.743	0.777	0.810
	0.544	0.579	0.615	0.650	0.685	0.721	0.756	0.791	0.827	0.862
	0.578	0.615	0.653	0.690	0.728	0.765	0.803	0.841	0.873	0.916
	0.612	0.652	0.692	0.732	0.772	0.812	0.851	0.891	0.931	0.971
35	0.648	0.690	0.732	0.775	0.817	0.859	0.901	0.944	0.986	1.028
	0.685	0.729	0.774	0.819	0.863	0.908	0.953	0.998	1.042	1.087
	0.722	0.770	0.817	0.864	0.911	0.959	1.006	1.053	1.100	1.147
	0.761	0.811	0.861	0.911	0.960	1.010	1.060	1.110	1.160	1.209
	0.801	0.854	0.906	0.958	1.011	1.063	1.116	1.168	1.221	1.273
40	0.842	0.897	0.952	1.008	1.063	1.118	1.173	1.228	1.283	1.339

* Volume over bark

Column numbers—Tree height in metres

Row numbers—Diameter at breast height in cm.

SUMMARY

Provisional volume tables for *Pinus caribaea* and *Pinus patula* have been prepared. Use has been made of 'Cosh function' as independent variable to improve volume (V) prediction by $V=a+b\ D^2H$ regression over entire data renge, where D is diameter at breast height and H is height of a tree.

दो विदेशी चीड़ों (*पाइनस कैरिबिया* और *पाइनस पैटुला* जातियां) का अन्तरिम आयतन

लेखक एस०पी० सिंह व एम०सी० मित्तल

सारांश

पाइनस कैरिबिया और *पाइनस पैटुला* की अन्तरिम आयतन सारणियां तैयार की गई है। इसमें पूरे व्यास की सीमा में आ=क+ख व्या^{2} × ऊं ($V= a+b\ D^2H$) प्रतीपायन द्वारा निकाले गए आयतन (V) को परिष्कृत करने के लिए स्वतन्त्र चर के रूप में 'कौशफलन' का उपयोग किया गया है। इसमें व्या (D) वक्षोच्चता पर वृक्ष का व्यास तथा ऊ (H) उसकी ऊंचाई हैं।

Reference

Singh, S.P. and Jain, R.C. (1980). Volume table for *Trewia nudiflora* (Gutel)—Application of Cosh function and dummy variable in volume estimation. *Indian For.*, **106** (10) : 696–702.

SOME IMPORTANT DISEASES OF HARD PINES IN INDIA

BY

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Many species of hard pines of both indigenous and exotic origin are being raised in India to meet the increasing demand of pulp and paper industry. A brief account of disease situation in nurseries and plantations of hard pines had been given by Sujan Singh *et al.* (1980). Since then more information on the diseases of hard pines has accrued from periodic surveys conducted by Disease—Insect Survey Unit of Directorate of Biological Research, Forest Research Institute, Dehra Dun. The present publication deals with a brief account on the current status of diseases of hard pines in the country.

Nursery diseases

Damping off: Damping off of seedlings in nurseries has continued to cause major losses in planting stock of hard pines. As the seeds of exotic pines are difficult to procure and their purchase involves high cost in foreign exchange, control of damping off should form an integral part of any nursery management programme. In North Bengal and Andhra Pradesh nurseries, the disease had been successfully controlled by sterilization of nursery soil with formaline @ 250 cc of commercial formaline diluted in 4 litres of water and applied to one square meter of nursery bed 10–12 days before sowing. In Jagdalpur nursery in Madhya Pradesh losses due to damping off have been successfully reduced by treating the soil with blitox or fytolan @ 200 gm of fungicide per cubic meter of soil.

Seedling wilt: Wilt of seedlings of many hard pines including *Pinus caribaea*, *P. elliottii* and *P. patula* was recorded in nurseries of New Forest, Kalsi, Gaza and Lohaghat in Uttar Pradesh and Sunada nursery in North Bengal. The first symptoms of the disease are manifested in the needles of growing shoots which become flaccid, droop down and finally dry up (Pl. 1, Fig. 1 and 3). The symptoms then advance downwards resulting ultimatly in death of whole seedling. Mortality due to this disease is more severe up to six months after pricking in the polythene tubes. A *Fusarium* sp. was consistently isolated from roots of dead and dying seedlings. No effective control measure has yet been evolved for this disease.

Cercospora needle blight: *Cercospora pini-densiflorae* Hori et Nambu, a pathogen inadvertently introduced in India continued to cause serious damage in pine nurseries. The pathogen was first described from India by Reddy and Pandey (1973) on *P. oocarpa* and *P. kesiya* in nursery and on *P. radiata* in Plantation from Amarkantak (Madhya Pradesh). Since then, Cercospora needle blight has been recorded from many localities. Main symptoms of the disease include drying of lower needles followed by death of the seedlings after the drying reaches the growing shoot (Pl. 1, fig. 5). A brief account of status of Cercospora needle blight in nurseries is given in Table 1.

Table 1

Cercospora needle blight in nurseries of indigenous and exotic pines

Nursery	Pine species	Seedlings assessed (No.)	Age of seedlings (months)	Disease incidence (%)
New Forest (Uttar Pradesh)	*Pinus caribaea*	5027	12	64–100
	P. elliottii	703	12	14.3
	P. oocarpa	2388	10	100
	P. patula	6910	6	100
Lohaghat (Uttar Pradesh)	*P. clausa*	5000	—	100
Kalsi (Uttar Pradesh)	*P. greggii*	4000	16	100
	P. roxburghii	2900	10–16	100
	P. elliottii	2600	10–16	100
	P. patula	2400	12–15	100
	P. kesiya	2000	10	100
	P. taeda	400	10	100
Dharamgarh (Uttar Pradesh)	*P. roxburghii*	1200	7	100
	P. elliotii	420	7	100
	P. patula	581	7	100
	P. greggii	120	7	100
Mohan (Uttar Pradesh)	*P. roxburghii*	3500		100
	P. elliottii	470		100
Jagdalpur (Madhya Pradesh)	*P. caribaea*	4585	13	100
		215000	2	NIL
Kurandi (Madhya Pradesh)	*P. caribaea*	100000	13	100
Anjoda (Andhra Pradesh)	*P. caribaea*	645	9	21.1
	P. oocarpa	582	9	91.2
	P. kesiya	255	10	65.1
	P. patula	180	9	96.1
	P. elliottii	34	9	100
	P. clausa	45	9	88.9
	P. echinata	120	9	96.7
	P. taeda	4	9	100
Maridumilli (Andhra Pradesh)	*P. kesiya*	700	11	40

Disease was absent in Chompi, Nitaput, Krisnapuram, Bordingula and Kitumala nurseries of Andhra Pradesh.

It was observed that Cercospora needle blight was serious in hard pines raised on unsuitable sites while same species of pines ramained free from Cercospora attack when these were raised on sites suitable for their healthy growth. *P. caribaea* and *P. patula*, for example, were free from Cercospora attack in Lohaghat and Kalika nurseries, Uttar Pradesh where pH of the potting mixture was 5.8 and 6.2 respectively and climate is favourable for their healthy growth. *P. clausa* seedlings placed side by side were heavily attacked by the disease. Both *P. caribaea* and *P. patula*, however, suffered heavily from Cercospora needle blight in New Forest, Kalsi and Satyanarayan nurseries of Uttar Pradesh where pH of potting mixture ranged from 7.4–8.54 and pH of water used for irrigation ranges from 7.8–9.46. Efforts to control Cercospora needle disease by use of chemicals on the basis of measures suggested by various workers (Reddy and Panday 1973, Jamaluddin *et al.* 1980) have so far not yielded positive results.

Diseases in plantations

Cercospora needle blight : *Cercospora pini-densiflorae* continued to develop further on seedlings of hard pines when infected seedlings from nurseries were planted in the field. A brief account of Cercospora needle blight in plantations of hard pines is given in Table 2.

Cercospora needle blight was absent in Kalika, Lohaghat, Sukhi Dhang, Amkhark, Dunaghat, Sui, Punethi, Gaina, Puneri and Bepul plantations in Uttar Pradesh; all plantations in North Bengal, Chompi, Netaput, Bordingula, Seatha Kandi plantations in Andhra Pradesh. In all plantations in Uttar Pradesh and in Chompi plantation of Andhra Pradesh, seedlings infected by Cercospora needle blight at the nursery stage had been planted in the field. Heavy infection of Cercospora blight was however, recorded on natural regeneration of *P. roxburghii* in Ajehri, Simgarhi, Dharmgarh and Sassola areas of Uttar Pradesh.

Following observations can be made from the data given in Table 2.

1. *P. radiata* appears highly susceptible to Cercospora needle blight. *P. oocarpa* is also attacked by the disease in field plantings and the susceptibility of this species needs to be observed with increase in plantation age.

2. Excepting *P. radiata* and *P. caribaea*, all other exotic pines appear to develop resistance against Cercospora needle blight after the plants get over the establishment shock. Attack of 2–4 year old plants of *P. caribaea.*, *P. kesiya*, *P. patula* and *P. pseudostrobus* by Cercospora needle blight in New Forest may be attributed to unsuitability of the site for the four species referred above.

3. *P. roxburghii* the indigenous pine, appears to be highly susceptible to Cercospora needle blight even at 15 years age.

Diplodia die-back : *Diplodia pinea* (Desm.) Kicks, the cause of die-back of pines was first recorded in India in 1972, on *P. patula* and *P. pseudostrobus* (Bakshi *et al.* 1972). Since then, the disease has been recorded in many other localities causing damages of economic importance. Main symptoms of the disease include die-back of terminal shoot of main stem and the branches. The infected plants become stunted with bushy growth due to repeated attack of the pathogen on the growing shoot (Pl. 1, Fig. 2). An upto date information on Diplodia die-back disease is given in Table 3.

Plate 1

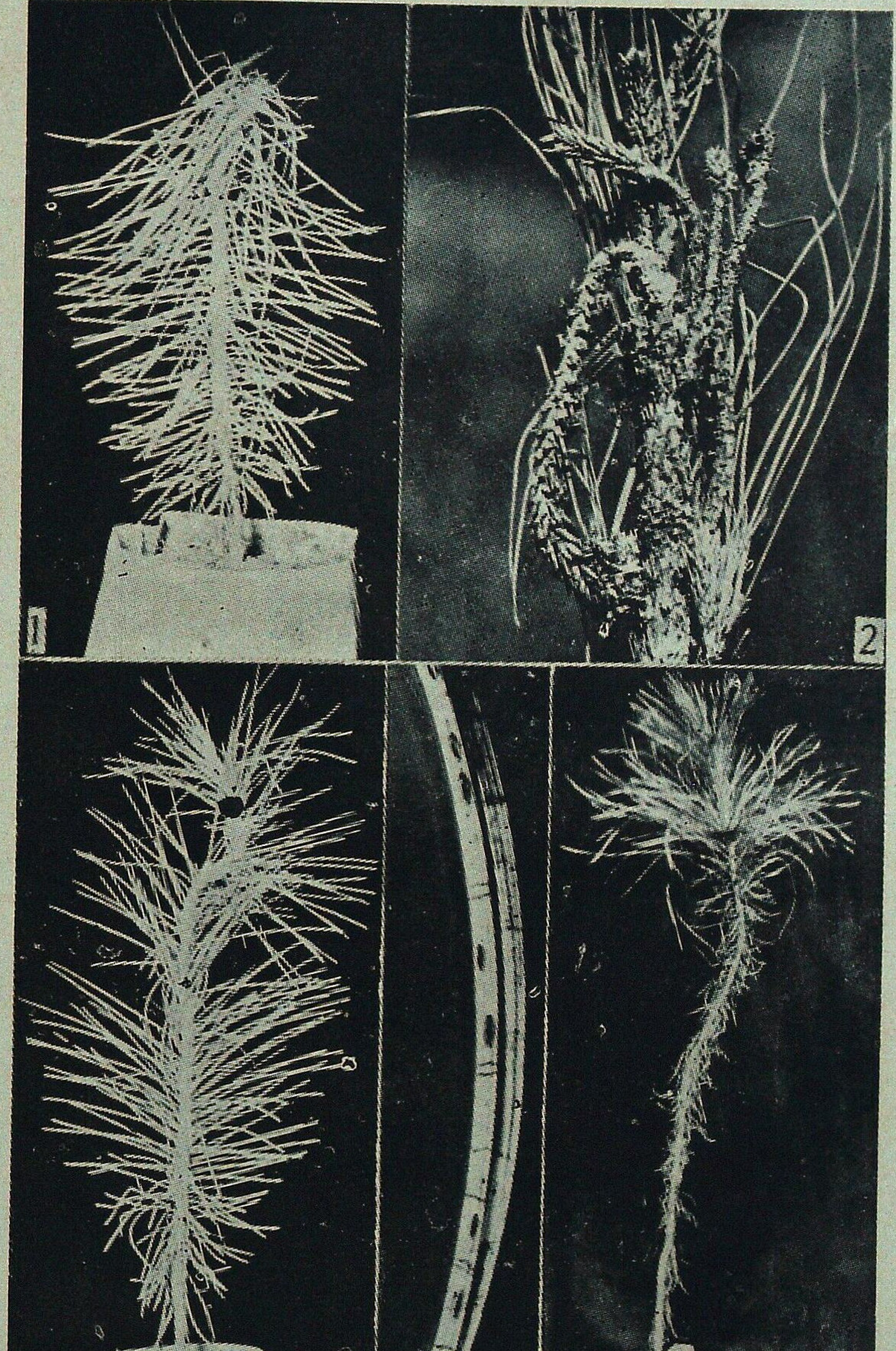

Fig. 1 & 3. *Pinus caribaea* seedlings affected by *Fusarium* wilt; 1, tip wilted and dead (×0.3); 2, bend in tip portion showing recovery from disease (×0.3). Fig. 2. *P. patula*, repeated die-back of growing shoot due to *Diplodia pinea* attack (×0.5). Fig. 4. *Lophodermium indianum* on needless of *P. roxburghii* (×5). Fig. 5. *P. greggii* seedling heavily attacked by *Cercospora pini-densiflorae* (× 0.25).

Table 2

Status of cercospora needle blight tn plantations of exotic and indigencus pines

Locality	Species	Age of plants assessed	No. of plants assessed	Incidence of infection (%)	Intensity of infection on infected plants**
New Forest (U.P.)	*Pinus caribaea*	5 months	91	100.0	Light to moderate
	Pinus caribaea	4 years	182	81.0	Light to moderate
	P. kesiya	4 years	28	61.9	Light to moderate
	P. patula	5 months	295	99	Light to heavy
	P. patula	2 years	514	78.4	Light to heavy
	P. patula	4 years	22	13.6	Light to moderate
	P. pseudostrobus	4 years	24	12.5	Light to moderate
	P. roxburghii	4 years	71	66.6	Light to heavy
	P. oocarpa	2 months	268	100.0	Light to heavy
Barham Sarovar (U.P.)	*P. greggii*	2 months	1140	100.0	Light
	P. roxburghii	2 months	240	100.0	Light
	P. elliottii	2 months	130	100.0	Light
Kalsi (U.P.)	*P. roxburghii*	*2 years	2500	100 0	Light to moderate
	P. roxburghii	10 years	10	20.0	Light to moderate
	P. greggii	*2 years	125	100.0	Light to moderata
	P. caribaea	*2 years	125	100.0	Light to moderate
	P. elliottii	*2 years	125	100.0	Light to moderate
Mohesh Khan (U.P.)	*P. radiata*	12 years	47	21.3	Light
Chandak (Pithoragarh, U.P.)	*P. roxburghii*	5-15years	—	—	Light to moderate
Kurandi (Jagdalpur, M.P.)	*P. caribaea*	4 months	200	100	Light to heavy
	P. oocarpa	4 months	2[illegible]	92	Light to heavy
Bhanpuri (Jagdalpur, M P.)	*P. caribaea*	*2 years	238	29.4	Light to heavy
Jam Gaon (Jagdalpur, M.P.)	*P. caribaea*	4 months	131	93.9	Light to heavy
Arku (A.P.)	*P. radiata*	15 years	7	100	Heavy
	P. oocarpa	*2 years	—	—	Light
	P kesiya	*2 years	—	—	Light
Maridumilli (A.P.)	*P. oocarpa*	2 years	—	—	Light

*Infection due to Cercospora needle blight on current years's replacements only.

**Light : upto 1/2 crown infected. Moderate : upto 2,3 crown infected. Heavy : more than 2/3 crown infected.

Table 3

Status of diplodia die-back in exotic pine plantations

Locality	Species	Age of plants (Years)	Area/ number of plants assessed	Incidence of infection (%)	Intensity of the disease on infected plants*
New Forest (U.P.) (Provenance trials)	*Pinus glabra*	4	22	18.2	Light to moderate
	P. greggii	4	21	66.6	Light to moderate
	P. leiophylla	4	21	42.8	Light to heavy
	P. kesiya	4	21	14.3	Light
	P. pseudostrobus	4	24	50.0	Light to heavy
	P. patula	4	144	97.3	Light to heavy
	P. patula	12	30	100.0	Light to heavy
Ajehri (Pithoragarh, U.P.)	*P. greggii*	5	85	—	Moderate
	P. pseudostrobus	5	670	—	Heavy
	P. patula	5	2713	—	Heavy
Gaina (Pithoragarh, (U.P.)	*P. pseudostrobus*	5	290	0.7	Heavy
Lonaghat, (U.P.)	*P. patula*	10	0.57 ha	rare	—
	P. rigitaeda	5	—	100	Heavy
	P. greggii	10	—	rare	Heavy
Kalika (Ranikhet, U.P.)	*P. pseudostrobus*	5	220	56.8	Light to heavy
	P. rigitaeda	—	8	100	Heavy

*Light : upto 1/2 of the crown infected. Moderate : upto 2/3 of the crown infected. Heavy : more than 2/3 of the crown infected.

Exotic pine plantations in Jagdalpur (Madhya Pradesh), dome areas of Andhra Pradesh and Orissa, North Bengal and Sukhidhang, Amkhark, Dunaghat, Sui, Punethi, Chandak, Puneri, Bipul, Simgari, Dharmgharh and Sassola plantations in Kumaon Hills of U.P. are so far free from Diplodia die-back disease.

Diplodia pinea generally establishes on trees through colonization of wounded tissues though it has been found to invade healthy unwounded tissues also (Gibson 1979). During present surveys, it was found that the pathogen acted as a primary pathogen on unwounded pine tissues. The infection started on young and fleshy new growth and then proceeded downwards. Characteristic stain in the wood and in the pith region indicating colonization of tissues by the pathogen was observed in some cases.

Lophodermium needle cast: *Lophodermium pinastri* (Schrad.) Chav. was first recorded in India by Sydow and Butler (1911) on needles of *P. wallichiana* from Kashmir. Since then, species of *Lophodermium* had been recorded on many hard pines of both exotic and indigenous origin and all these collections had been identified as *L. pinastri*. A detailed study of a large number of collections made during disease surveys revealed that more than one species of *Lophodermium* are involved. The commonest fungus collected on needles of *P. roxburghii*

(Pl. 1, fig. 4), *P. caribaea*, *P. glabra*, *P. patula*, *P. serotina*, *P. taeda* and *P. thunbergii* from New Forest, Sukhidhang, Amkhrak and Ranikhet plantations in Uttar Pradesh was found to represent a new species and was named as *Lophodermium indianum* Sujan Singh and Minter (Minter 1981). This species appeared to be a weak parasite as it was found to attack mature needles at the time of needle fall.

Species of *Lophodermium* have also been recorded on *P. caribaea*, *P. echinata*, *P. elliottii*, *P. greggii*, *P. kesiya*, *P. mesogeensis*, *P. taeda* and *P. thunbergii* from Sukhidhang, Amkhark, Lohaghat, Ranikhet and Mahesh Khan plantations in Uttar Pradesh and on *P. densiflorae*, *P. kesiya*, *P. patula* and *P. taeda* from plantations in North Bengal. The exact identity of these species of *Lophodermium* and damage caused by them on infected pines is not known.

Trimmatostroma needle disease: *A Trimmatostroma* sp. commonly occurs on needles of *P. roxburghii* in New Forest (Uttar Pradesh) and in Himachal Pradesh. The impact of attack of *Trimmatostroma* sp. on growth increment of infected plants needs however to be studied. The fungus has not however been found to attack any of the exotic pines raised in the vicinity of infected plants of *P. roxburghii*.

SUMMARY

The paper deals with the current status of important diseases of hard pines in India. In nurseries, damping off, seedling wilt and Cercospora needle blight were found to cause losses of economic importance. While damping off disease has been successfully controlled by use of chemicals, no control of seedling wilt and Cercospora needle blight has yet been evolved. In plantations, *Pinus radiata* **and to some extent** *P. oocarpa* **among exotic pines and** *P. roxburghii,* **the indigenous pine, were found susceptible to Cercospora needle blight. Diplodia die-back of exotic pines was recorded in some plantations in Uttar Pradesh. The disease was found absent in exotic pine plantations of Andhra Pradesh, Madhya Pradesh and North Bengal.** *Lophodermium indianum* **Sujan Singh and Minter, occurring commonly on mature needles of** *P. roxburghii* **and many exotic pines was found as a weak parasite and is thus of no potential importance.**

भारत में कठोर चीड़ों के कुछ महत्वपूर्ण रोग

लेखक सुजान सिंह, एस०एन०खान, बी०एम० मिश्र व कमला उनियाल

सारांश

इस अभिपत्र में भारत के कठोर चीड़ों के महत्वपूर्ण रोगों की वर्तमान स्थिति बताई गई है। रोपणियों में आर्द्रगलन, पौधे मुरझाना और सरकोस्पोरा से पत्तियां झड़ने से आर्थिक दृष्टि से गणनीय हानि पहुंचती देखी गई। आर्द्रगलन रोग को रसायन पदार्थों द्वारा सफलतापूर्वक नियंत्रित कर लिया गया है किन्तु पौधे मुरझाने और सरकोस्पोरा से पत्तियां झड़ने का उपाय अभी तक नहीं निकल पाया है। रोपवनों में, *पाइनस रेडियाटा* और विदेशी चीड़ों में कुछ सीमा तक पा० *ऊकार्पा* तथा देशी चीड़ पा० *राक्सबर्घिआई* सरकोस्पोरा से पत्तियां झड़ने से प्रभावित होते पाए गए। विदेशी चीड़ों में *डिप्लोडिया* से शीर्ष शुष्कन उत्तर प्रदेश के कुछ रोपवनों में होता बताया गया है। यह रोग आंध्रप्रदेश, मध्य प्रदेश और उत्तर बंगाल के विदेशी चीड़ वनों में नहीं हुआ। *लोफोडर्मियम इंडियानम* सुजान सिंह व मिंटर जो आम तौर से पा० *राक्सबर्घिआई* की प्रौढ़ पत्तियों और अनेक विदेशी चीड़ों पर लगता पाया जाता है अशक्त परजीवी पाया गया और इस लिए उसका कोई विशेष महत्व नहीं है।

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INSECT PESTS OF EXOTIC PINES IN INDIA

By

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Introduction

To meet the ever growing demand for long fibre material from pulp and paper industry in the country, there is a search for fast growing tree species. Tropical pines of exotic origin are one such promising group of tree species which can meet this challenge and a good number of them are being raised in trial plantations (Map). Besides, two indigenous pines, *Pinus roxburghii* and *P. kesiya* are also being tried outside their natural range thus making them also 'exotic' in their new homes. When a large scale monoculture, of any tree species is raised, there is always the risk of pest build-up leading to epidemic outbreaks. These pest epidemics sometimes become a chronic feature of such monocultures causing loss in increment, forking, die-back, and in extreme cases even the death of plants on a large scale leading to failures in planting programmes. There are many examples from world forestry to substantiate the havoc caused by pests to monocultures particularly exotics.

With exotic pines we may face problems from either indigenous insects changing over to them from broad leaved species or as in the present case, native pests of indigenous pines may also adapt themselves to the introduced species. But a greater danger comes from those insects of these species which occur in their native habitats and get inadvertently introduced in their new homes. Continued surveillance is therefore necessary to detect any such inadvertent enteries of foreign pests, so that they can be destroyed before they go beyond our control. Surveillance is also necessary to record new pest outbreaks and to evaluate the status of prevailing pests. With this objective in view and the importance of pine planting programmes in the future, a survey of diseases and insects of exotic pines was started sometimes back. An account of insects recorded from exotic pines so far is given below.

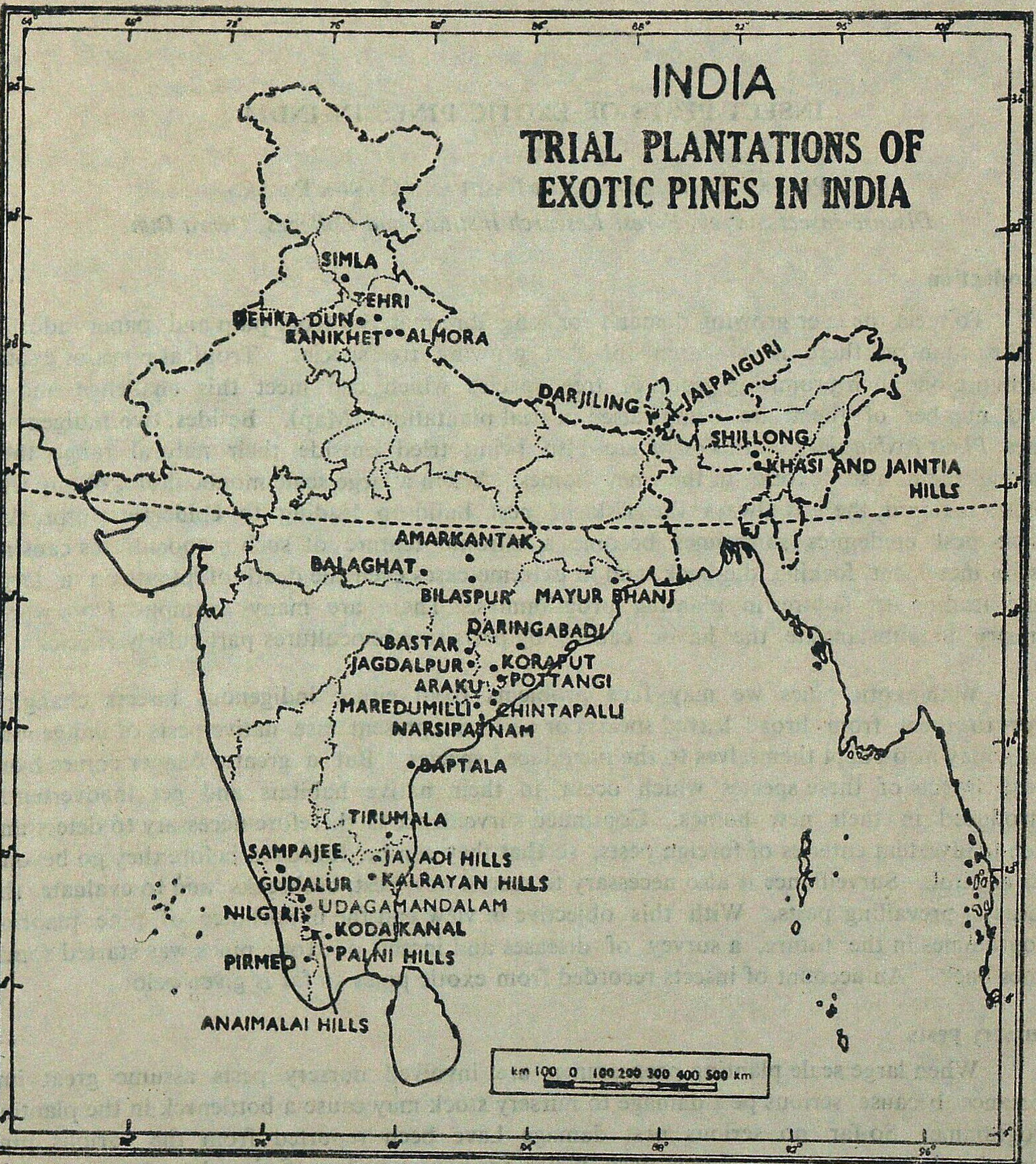
Nursery pests

When large scale planting programmes are involved nursery pests assume great importance because serious pest damage to nursery stock may cause a bottleneck in the planting programme. So far no serious pest damage have been reported from the various pine nurseries in the country. Some pests which are casual feeders of pines have been recorded. Most of them tend to be ephemral and local. The only pest of some consequence doing damage to pine seedlings are cutworms reported from New Forest nurseries.

Lepidoptera

Agrotis ipsilon Hufnagel **(Figs. 1-3, Plate I)**

This cutworm, damaged seedlings of *P. caribaea* and *P. oocarpa* causing 6.6 per cent mortality in New Forest, in 1978. Before the pest could cause much damage, the seedlings



INDIA

TRIAL PLANTATIONS OF EXOTIC PINES IN INDIA

SIMLA
TEHRI
DEHRA DUN
RANIKHET
ALMORA
DARJILING
JALPAIGURI
SHILLONG
KHASI AND JAINTIA HILLS
AMARKANTAK
BALAGHAT
BILASPUR
MAYUR BHANJ
DARINGABADI
BASTAR
JAGDALPUR
KORAPUT
ARAKU
POTTANGI
MAREDUMILLI
CHINTAPALLI
NARSIPATNAM
BAPTALA
TIRUMALA
SAMPAJEE
JAVADI HILLS
GUDALUR
KALRAYAN HILLS
UDAGAMANDALAM
NILGIRI
KODAIKANAL
PIRMED
PALNI HILLS
ANAIMALAI HILLS
km 100 0 100 200 300 400 500 km

Based upon Survey of India outline map printed in 1979

The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

The boundary of Meghalaya shown on this map is as interpreted from the North-Eastern Areas (Reorganisation) Act, 1971, but has yet to be verified

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were sprayed with 0.1 per cent aldrin which gave 70 per cent kill. Cutworms are also serious pests in conifer nurseries in the Himalaya. As cutworms, are widely distributed all over the country, they may cause problems in pine nursery beds anywhere. The cosmopolitan *A. ipsilon* has been reported damaging pine seedlings in many countries. The moth which has long narrow, brown and black forewings with a span of about 40 to 50 mm and pale hindwings, is nocturnal in habit and lays its eggs on the ground litter, showing a preference for moist sites. A fully grown larva may be about 35 mm long, its body smooth with very short hairs, earth coloured, speckled white or black and with some large skin-granules; when disturbed it characteristically curls itself into a C on its side. The larvae hide in the soil by day, emerge from the soil at night and cut young seedlings off at ground level or removing buds and needles, pupation takes place in the soil. In northern India its life cycle occupies from 5 to 9 weeks and during a year there are several generations, one of which overwinters in pupal stage.

Heliothis armigera Hubner, the cotton boll worm (Figs. 4–6, Plate I).

The larvae of this moth have been recorded feeding on the needles of *Pinus caribaea* and binding them together in Oosri nursery, Jagdalpur (M.P.). It has also been recorded defoliating young plantations of *P. patula* in New Zealand (Wormald, 1975). It is polyphagous and cosmopolitan species, widely distributed in India. The moth is stoutly built and yellowish brown in colour. There is a dark speck and a dark area near the outer margin of each forewing. The forewings are marked with greying wavy lines and black spots of varying size on the upper side and a black kidney shaped mark and a round spot on the underside. The hind wings are whitish and lighter in colour with a broad black band along the outer margin. Eggs are round and greenish yellow in colour and laid singly. Incubation period is 2–4 days in April to October and 6 days in February. The caterpillar is greenish with dark broken grey lines along the sides of the body measuring 30–40 mm in length when full grown. Larval period is from 13–19 days. Pupa is dark brown in colour, pupation takes place in soil. Pupal period is from 8–15 days. There may be 8 generations in a year with hibernating pupa in winter. The larvae are sometimes predaceous on other larvae including their own species. The pest can be controlled by spraying the plants with 0.1% carbaryl.

Orthopters

Grass hoppers i.e. *Chrotogonus* sp. (Fig. 6 Plate II) *Caloptenopsis* sp., *Gatantops indicus*, Saussure, *Oxya velox* Fabricius, have been recorded feeding on *P. caribaea*, *P. oocarpa* and *P. kesiya* at Jagdalpur (Madhya Pradesh) and New Forest. Sometimes crickets and gryllids also attack the seedlings. They attack suddenly in the night and leave just as suddenly, usually before any control measures can be affected. Use of wiremesh gives effective protection to pine seedling against grasshoppers. Dust with 5% BHC @ 20–25 kg per hectare for control.

Coleoptera

In north India some mortality of seedlings of *P. patula*, *P. caribaea*, *P. greggii* and *P. oocarpa* has been caused by chafers *Mimela mundissima* Walker (Searabaeidae), *Anomala rufiventris* Redtenbacher (Rutelinae), *Granida albosparsa* (Melolonthinae), *Hilyotrogus holosericea* Redtenbacher (Melolonthinae). The grubs live in soil and feed on roots. No serious damage has been reported from any of the nurseries. However, 2.2% mortality due to the chafer was reported from out planting in New Forest. Chafers in nurseries can be controlled by mixing 10% BHC dust @ 12.5 kg (a.i.) per hectare.

Isoptera

Termite damage has been reported from pine nurseries in Jagdalpur area (Figs. 3 & 4, Plate II). It can be effectively controlled by spraying 0.1% of any of the soil insecticides i.e. B.H.C., Aldrin, Chlordance, or by mixing the nursery soil with insecticidal dust at the time of preparation of soil.

Aves (Birds)

Various species of birds sometimes play havoc in the nursery. Seed beds can usually be protected with wire-netting. Donald (1968) recommended repellent T.M.T.D. (Trimethylthiruam disulphide) as a repellent. This chemical is also known as Thiram or as Thiurol. The recommended treatment is:

T.M.T.D. @ 15% seed weight (TMTD is phytotoxic to seedlings if applied at too high a concentration).

Endrin @ 25% seed weight, (effective against field mice, can be omitted if they are no problem).

Terolaze @ 70 cc per kg of seed (a sticker to prevent TMTD washing off on the seedlings).

The seed should be soaked in water (if that is considered to improve germination), then put in a plastic bag and shake up with the sticker; T.M.T.D. and Endrin should then be added and the bag shaken again; finally the seed should be dried in the sun before sowing.

Rodents (Mammalia)—

(i) Squirrels (Fig. 7, Plate II). In the New Forest nursery, Squirrels caused damage to the freshly sown seeds in the seed beds. Chilli powder applied with a sticker (gum) to the seeds before sowing discouraged them from nibbling the seeds giving satisfactory protection.

(ii) Rats. In some nurseries field rats do considerable damage. Rats can be controlled by giving the treatment recommended as above or by using Aluminium phospide mixed baits.

Plantation pests

Most forest insects attacking exotic pines in plantations belong to the order Lepidoptera with lesser number in Coleoptera, Hemiptera, Orthoptera, Hymenoptera and Isoptera (Table 1). In most areas where exotic pines have been introduced, no true forest insect have adapted to feeding of pine after canopy is closed. The majority of the insects recorded are defoliators. In the north and north-east, both defoliators and shoot borers are potentialy devastating. Foresters have noticed and reported the damage to tropical pines only by a sap-sucking insect, mealy bug from south India (Seth, 1961).

Plate 1

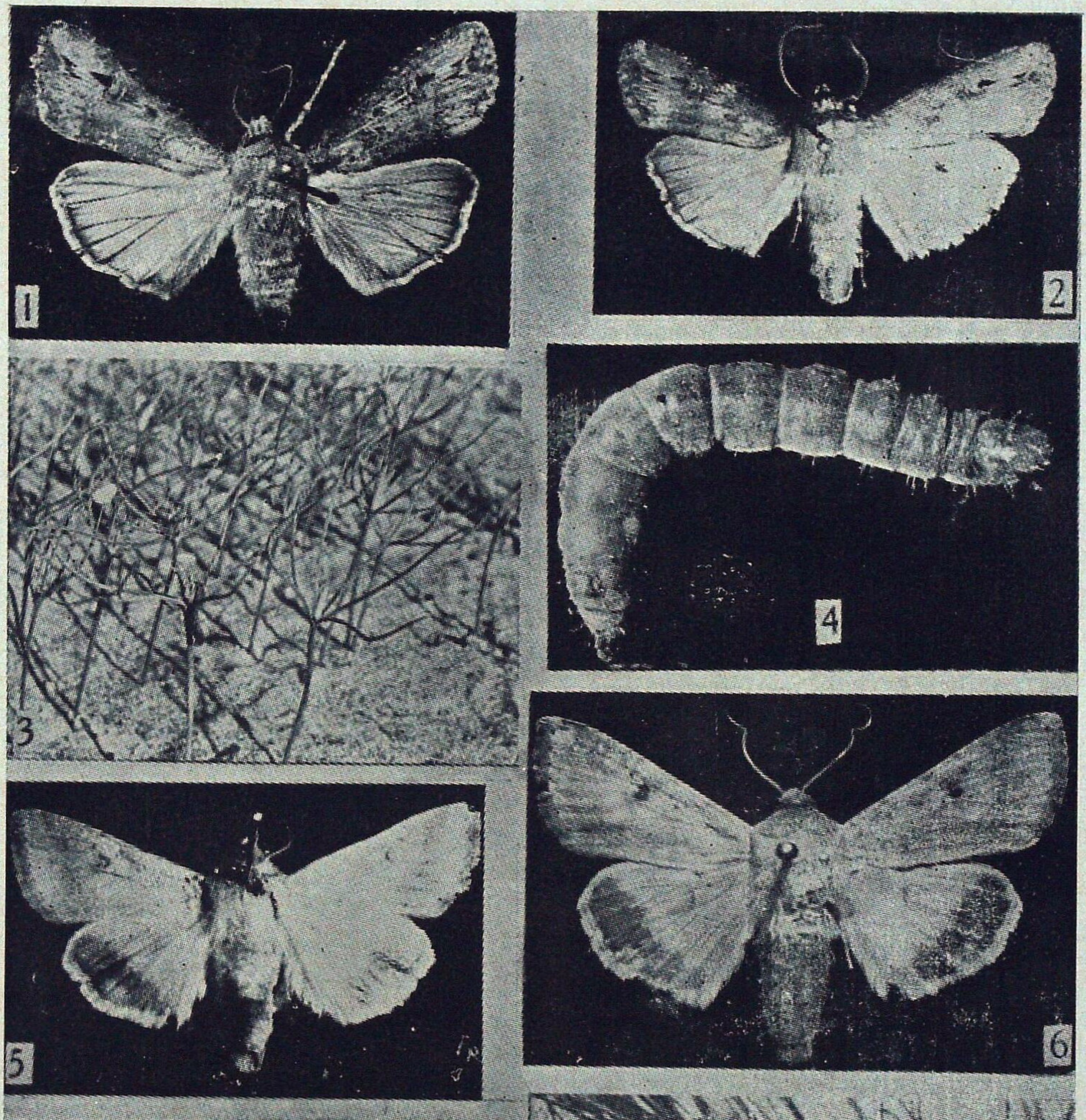
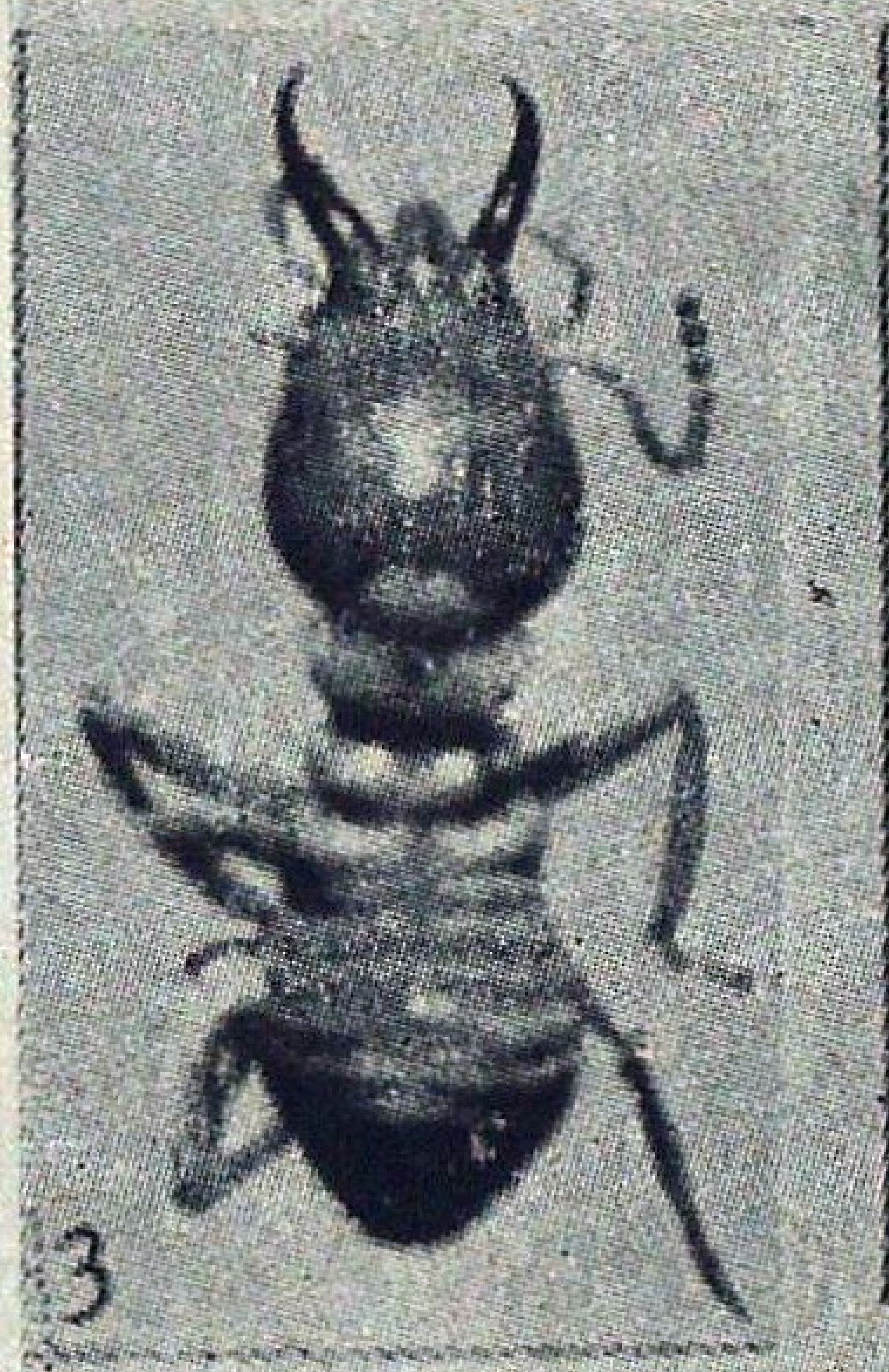
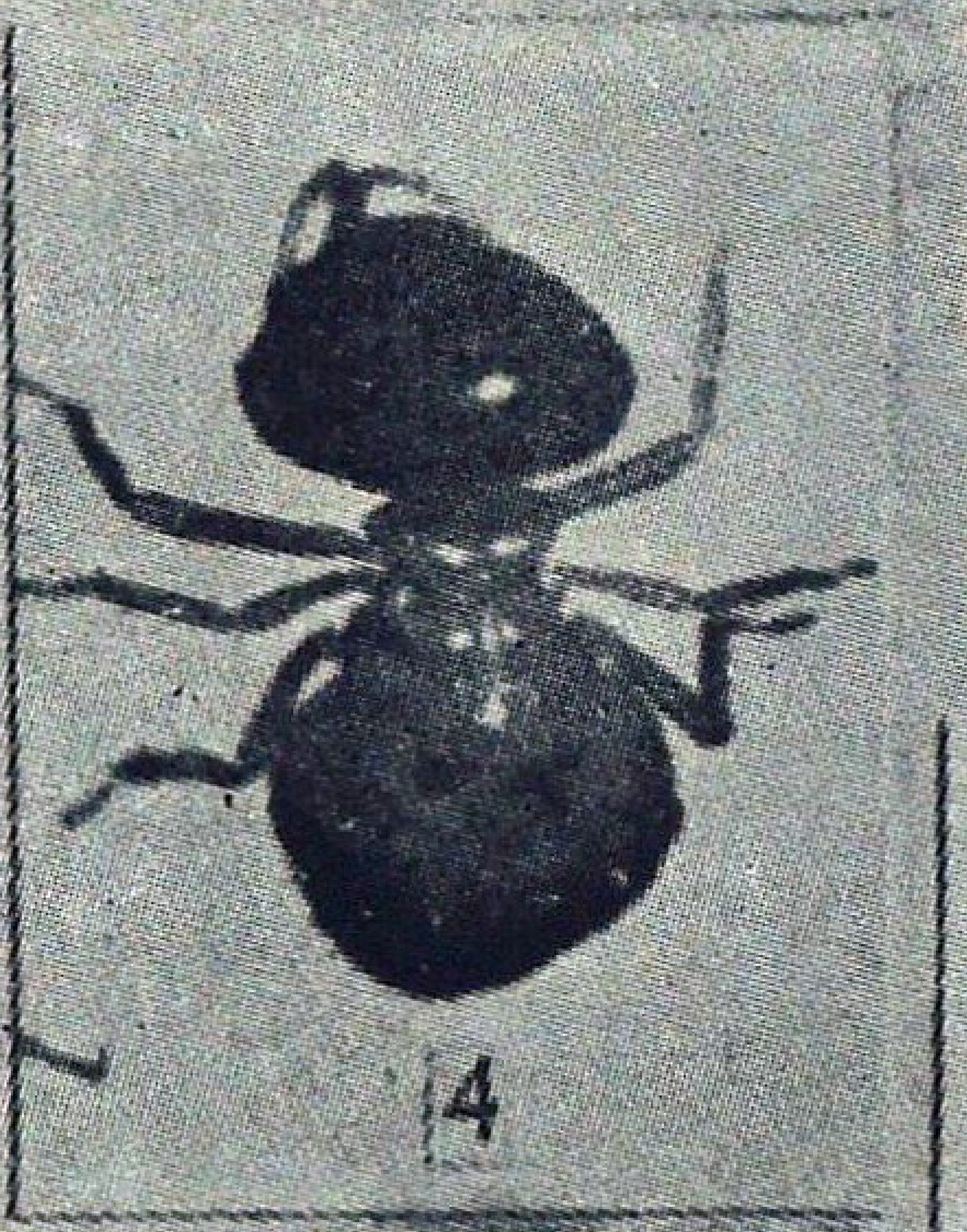
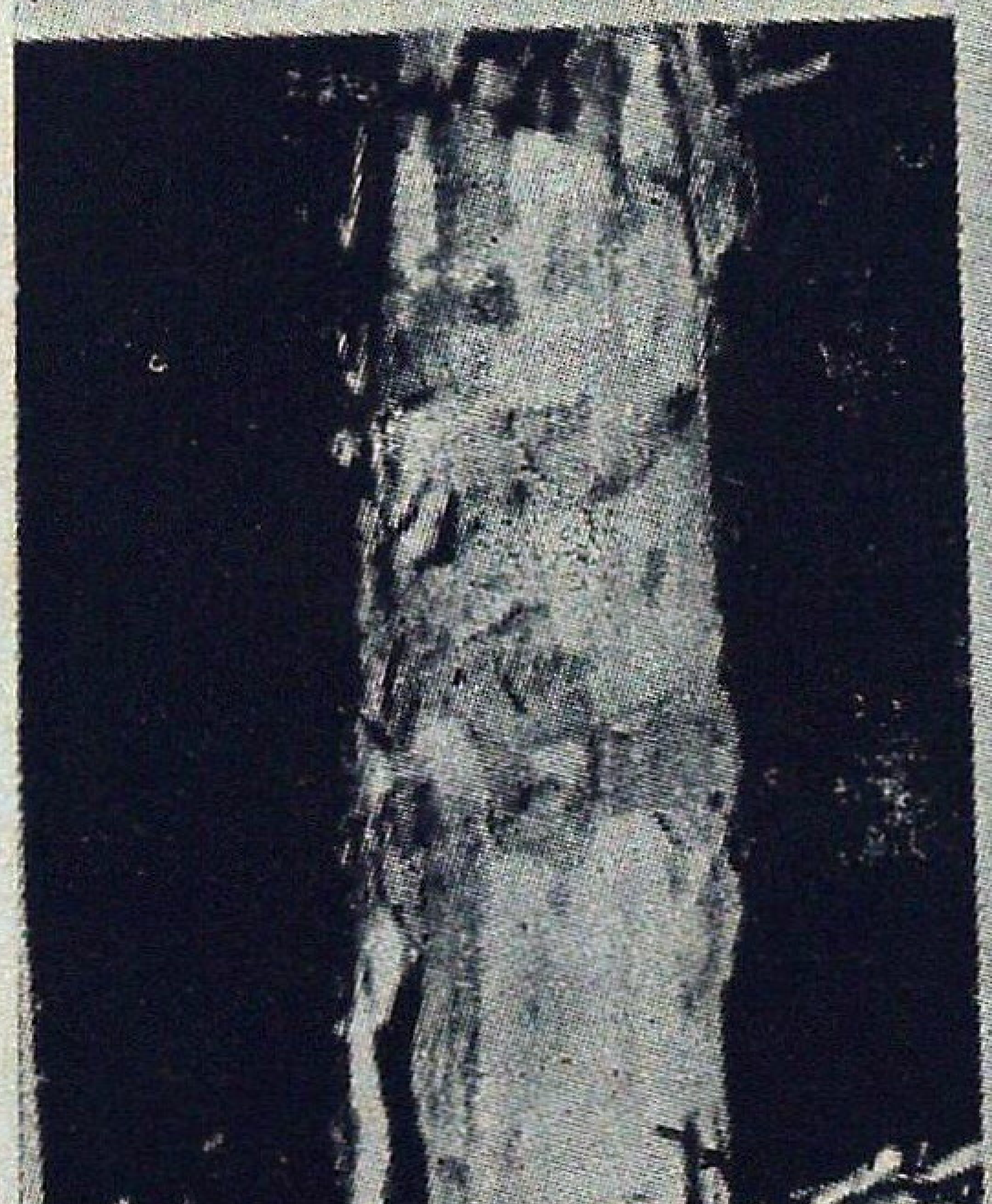


Fig. 1. Female moth of *Agrotis ipsilon* ; 2. Male moth of *A. ipsilon* ; 3. Larva of *A. ipsilon* damaging the seedling of *Pinus caribaea* ; 4. Mature larva of *Heliothis armigera* ; 5. Male moth of *H. armigera* ; 6. Female moth of *H. armigera* ; 7. Damage to *Pinus patula* by larvae of *Cryptothelea crameri* ; 8. Moth of *C. crameri*.

Plate II







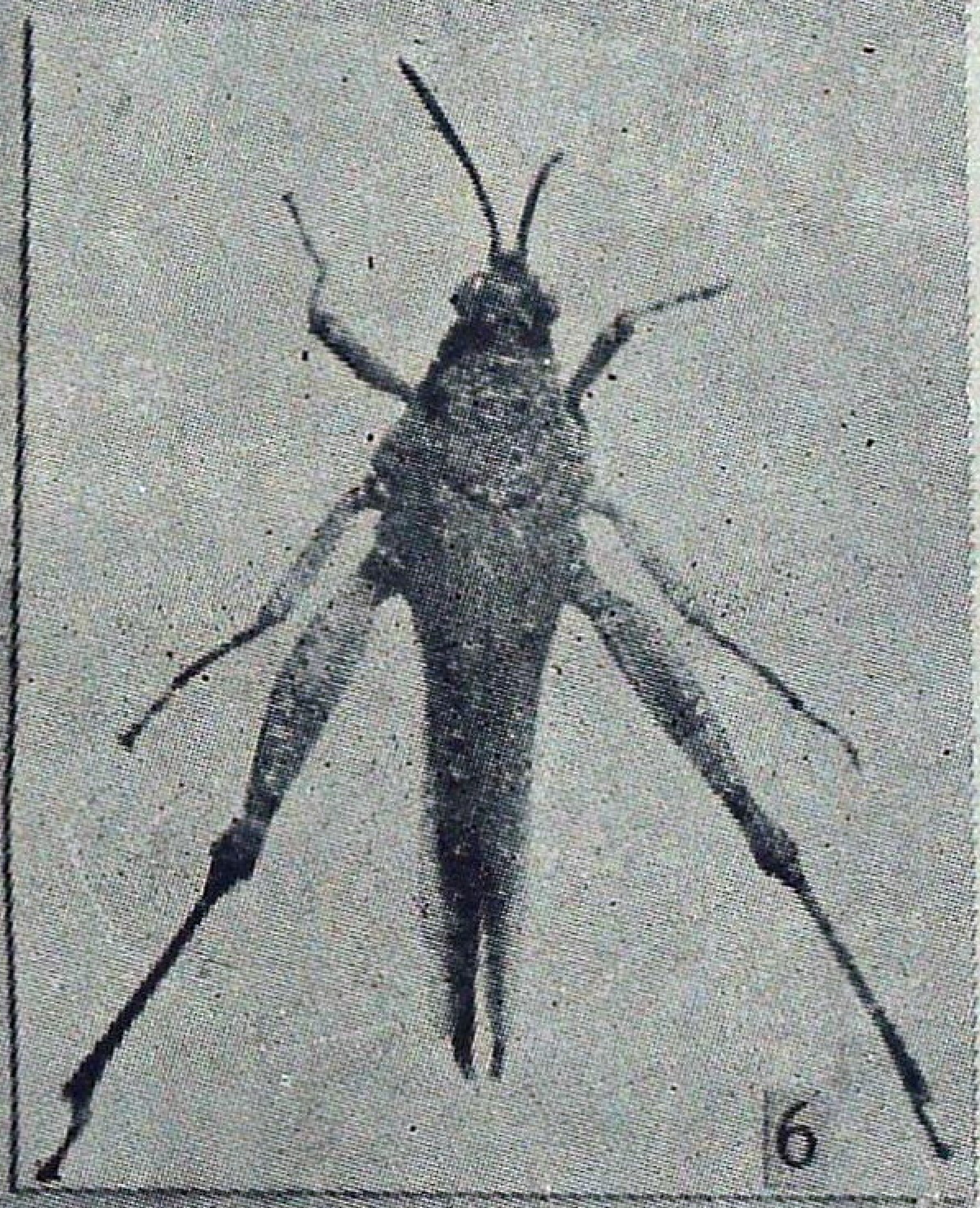


Fig. 1. Adelges, *Pineus laevis* on *Pinus oocarpa* ; 2. *Chionaspis chir* attack on needles of *Pinus greggii* ; 3. Soldier of *Odontotermes obesus* ; 4. Worker of *O. obesus* ; 5. Roots and stem of *Pinus caribaea* damaged by *O. obesus* ; 6. *Chrotogonus* sp. adult ; 7. *Funambulus pennanti*.

Hemiptera

Sap suckers, *Pine adelgid, Pineus laevis* Maskell (Fig. 1, Plate II). The most important pest of exotic pines that occurs in India is the pine adelgid, *Pineus laevis* Maskell. This insect has been recorded attacking pines in South America, Australia, New Zealand, South Africa, Rhodesia, Tanzania and Kenya. Well established infestation of *Pineus* are found in India in Kodaikanal, Topslip and Udagamandalam (Tamil Nadu) and Mannar, (Kerala). The lifecycle of this adelgid is probably anholocyclic (the number of changes in body form incomplete). Throughout its range, it is exclusively associated with *Pinus* spp. In India it has been recorded from *P. radiata, P. kesiya, P. oocarpa, P. montezume* (Singh, 1975). Damage which consists of death of terminal bud leading to malformation, stunting and even death of the whole tree, is most evident when pines are raised on poor sites. All age groups of plants are affected.

Indigenous adelgids, *Pineus* spp. occur on chir pine in north-west Himalaya (Yaseen and Ghani, 1971) and Khasi pine in Meghalaya. In their natural habitat these adelgids seldom cause economic damage apparently they are kept under check by the large number of predators that prey upon them. The adelgid, occurring in south India, *Pineus laevis*, appears to be an inadvertent introduction from Europe and north America, to date confined to south India (Nilgiris, Anaimalai and Palni Hills) only. As the adelgid assumes serious proportion in the absence of its natural regulating mechanisms an effort should be made to control the pest by the introduction of promising predators from the Himalaya. Foliar spray of 0.1% Malathion solution in water gives satisfactory control. Insect surveys so far conducted reveal that the adelgid is absent from Jagdalpur, Araku and Koraput belt (Dom area) where tropical pines are being introduced on a large scale. Hence care should be taken that no planting stock of pines be imported into this area from either south India or from north and north-east India, so that these adelgids do not gain entry into the region. In case, any infestation of the adelgids is reported, from Dome areas or any adelgid free area, the infested planting stock and the plantations should be thoroughly sprayed with 0.1% Malathion solution in water which will nip the evil in the bud.

Pine coccid (*Ripersia resinophila* Green). *R. resinophila* is a coccid which sometimes attacks chir and khasi pines in their habitat leading to shoot injury. No economic damage has so for been reported from its natural range. The reported occurrence of this coccid on *P. radiata, P. caribaea, P. kesiya* from Palni Hills, Tamil Nadu (Lamb, 1973) requires confirmation.

Mealy bug. Seth (1972) reports damage to pines in south India by a mealy bug which appears to be a case of mistaken identity. The insect called mealy bug was presumably adelgid, *P. laevis*.

Chir coccid (Fig. 2, Plate II). Another indigenous coccid, *Chionaspis chir* Green, of chir pine has also been recorded from a few plants of *P. caribaea, P. greggii* and *P. teada* from New Forest in 1979.

Defoliators

Lepidoptera

Most of the Lepidoptera recorded defoliating tropical pines are casual feeders. The most commonly occurring family is Psychidae (bagworms). *Cryptothelea crameri* Westwood (Figs. 7 & 8, Plate I) epidemics have been reported in chir forests from north-west India (Singh, 1957). An allied species causes epidemics in *P. patula* plantations in South Africa. There are four species of unidentified psychids recorded feeding on exotic pines. A lymantrid defoliator *Orgyia postica* Walker (Figs. 7–12, Plate IV) is also a potential pest of pines as allied species, *O. anartoides* Walker and *O. australis,* defoliate *P. radiata* in Australia and *O. basalis,* Walker, *O. hopkinsi* Collenette and *O. mixta* Snellen, defoliate nursery stocks of *P. patula* and *P. radiata* in South Africa. *Metanastria ampla* (Figs. 1–6, Plate VI) Walker and *M. grisea* Moore defoliate *P. kesiya* in north-east India. Though mainly broad leaved defoliators, they are potential pests of pines.

Eterusia pulchella Koll (Figs. 1–5, Plate III).

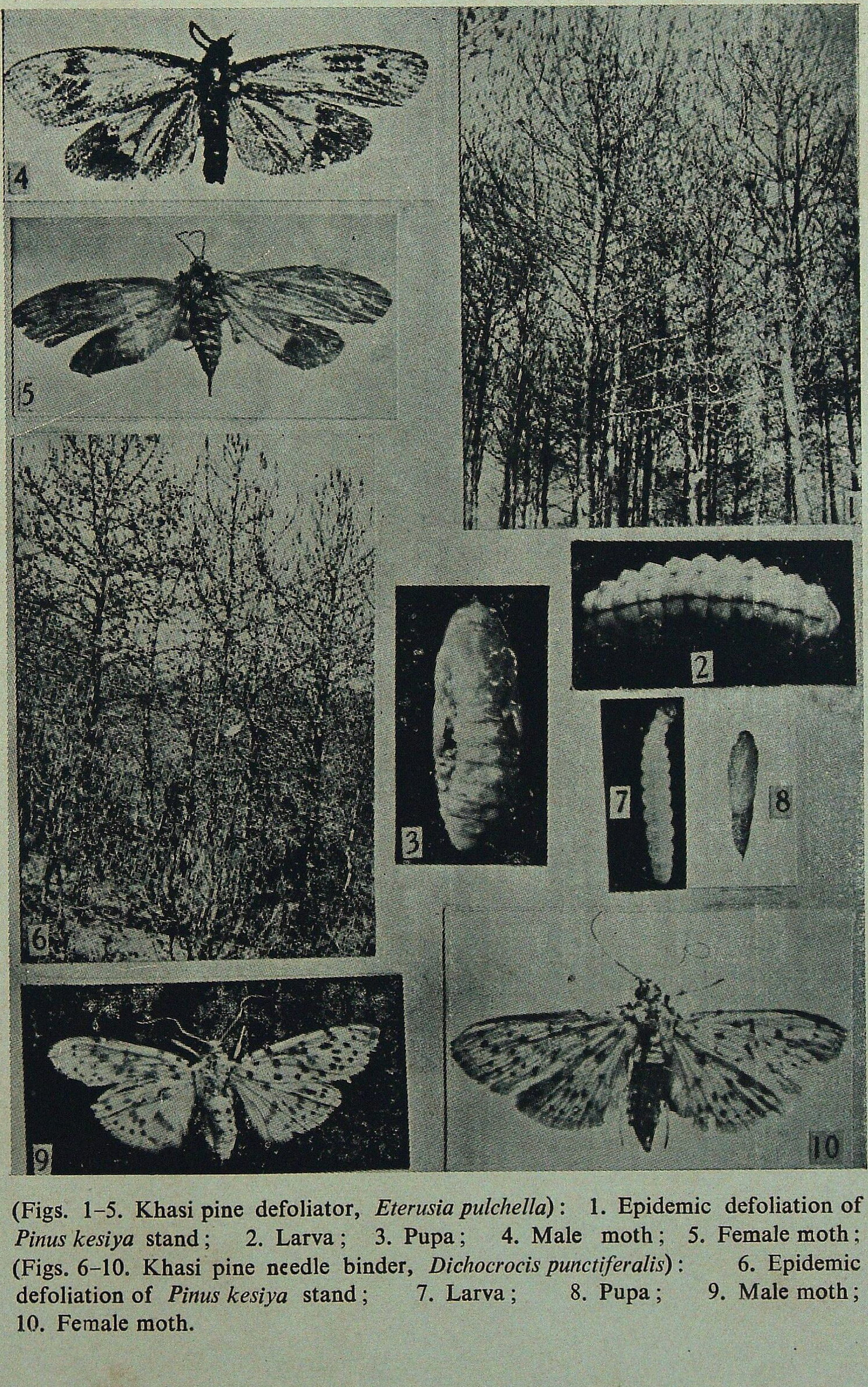
An epidemic defoliation of Khasi pine (*P. kesiya*) by a zygaenid moth, *E. pulchella,* was first noticed in Meghalaya in 1971 at Sumer in Khasi Hills and later in Khasi and Jaintia Hills in 1972 and 1975 affecting an area of 2,500 hectares in Khasi Hills and 7,500 hectares in Jaintia Hills respectively. The intensity of attack was from moderate to heavy. All age classes of trees were attacked. Heavily infested trees in affected areas died in patches (Singh & Singh, 1978). Since then there are no reports of any epidemic defoliation but this insect appears to be a potential pest of exotic pines particularly *P. kesiya.* Therefore, care should be taken so that it should not invade either Dome areas or south India.

E. pulchella is a polyphagous species recorded from Afganistan to Tonkin. Egg is cream coloured laid on needles and spurs. Mature larva is robust slug like. head chestnut brown, body pink brown. Pupa light brown in colour somewhat flattened dorso-ventrally. The moth is variable, sexually dimorphic species. The colour is black and light yellow. In the male the collar, in the female usually also the whole neck is red. Abdomen in the female white with metallic blue bands. Moths are diurnal in habit, on wing in March-April and in June to October. Eggs are laid in clusters. Incubation period is 5 days in March. Newly hatched larvae feed on tender needles. There are five larval instars. Larval period is 15–20 days in March–April. Last larval instar spins a silken white cocoon. Pupal period is 10–14 days. There may be 10–12 generations in a year. For control spray 0.1% carbaryl in water solution (Singh & Singh, 1978).

Dichocrocis punctiferalis Guenee (Figs. 6–10, Plate III).

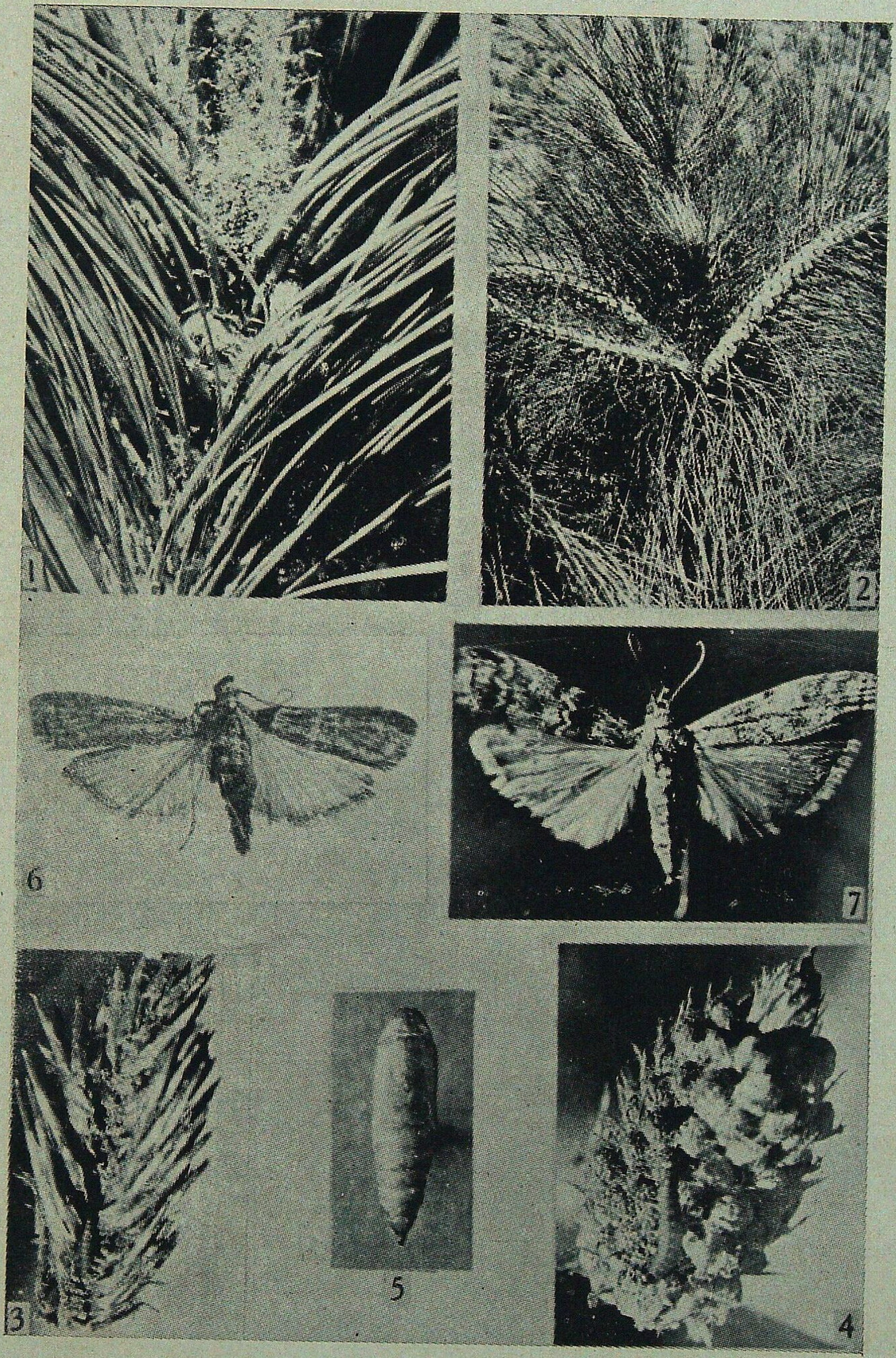
During *E. pulchella* epidemics, another insect identified as *Dichocrocis punctiferalis,* was also involved in large scale defoliation in Khasi and Jaintia Hills. The area involved in defoliation was quite extensive and defoliation was also complete. Though *D. punctiferalis,* too is primarily a pest of broadleaved species but the danger from this insect is very high as this insect is widely distributed all over India feeding upon fruits of castor, teak, mango, etc.

Plate III



(Figs. 1–5. Khasi pine defoliator, *Eterusia pulchella*): 1. Epidemic defoliation of *Pinus kesiya* stand; 2. Larva; 3. Pupa; 4. Male moth; 5. Female moth; (Figs. 6–10. Khasi pine needle binder, *Dichocrocis punctiferalis*): 6. Epidemic defoliation of *Pinus kesiya* stand; 7. Larva; 8. Pupa; 9. Male moth; 10. Female moth.

Plate IV



Figs. 1–7. Pine cone and shoot moth, *Dioryctria abietella* :
1. Frass expelled by the borer from the leading shoot of *Pinus roxburghii* ; 2. Leader of *P. roxburghii* killed by the borer ; 3. Larva inside the shoot of *P. roxburghii* ; 4. Larva with ejected frass on male cone of *P. roxburghii* ; 5. Dorsal view of pupa ; 6. Male moth ; 7. Female moth.

The larva of this moth is polyphagous and sometimes is a serious pest of castor and teak seeds. The egg is oval and pinkish in colour. The full grown larva is 17–24 mm in length, pale greenish, pink to light brown in colour. Pupa is reddish brown. The adult is a medium sized moth. Bright yellow to orange yellow in colour with black spots on the wings and the abdomen. Moths are nocturnal. Eggs are laid on cones and young shoots. Incubation period is from 2–6 days. The larvae feed gregariously under web, binding needles in a bunch Larval period varies from 12–38 days and the pupal period from 7–12 days Insect completes its life cycle in 23–70 days in different months of the year. There may be 5–6 generations in a year. The pest can be controlled by spraying 0.1% carbaryl in water solution.

Coleoptera

Sometimes scarabid beetles, *Melolontha, Adoretus* and *Anomala* species when swarming in large numbers defoliate young exotic and indigenous pines in the Himalaya. Chrysomelid beetles, *Aetheomorpha nigropicta* Lefebvre, *Aphthona nigrilobris* Duvivier. *Colasposoma semicostatum* Jacoby, *Gallerucida rutilans* Hope, *Hoplasoma sexmaculata* Hope, and *Nodina crassipes* Jacoby, have been recorded defoliating chir pine in the northern region. These species sometimes graze needles of tropical pines i.e. *P. caribaea, P. patula, P. kesiya* and *P. oocarpa.* No extensive damage due to these beetles has been reported so far.

Weevils

In 1978 *Dereodus pollinosus* Redt. and *Xanthochelus faunus* Oliv. caused severe defoliation of *P. greggii. P patula* and *P. taeda* in Almora forest division, U.P. (Gupta, 1978). Normally adults of both these weevils defoliate broadleaved species (Beeson, 1941, Lefroy, 1909).

Dereodus pollinosus Redt. (Figs. 17 & 18, Plate V).

In May when swarming takes place these beetles load their hosts at some places and completely defoliate them. Adult is an elongate black weevil dusted with yellowish and pinkish scales, length is about 12–17 mm, male smaller then female. Life-history of the species is unknown.

Xanthochelus faunus Oliv. (Figs. 15 & 16, Plate V).

X. faunus is a large grey weevil about 20 mm long; male smaller than female. Life-history of the species is not known.

Hymenoptera

Saw flies

Athalia nigromaculata sikkimensis Benson has been recorded defoliating chir pine in the Himalaya (Beeson, 1941), *Neodiprion biramis* defoliates *Pinus kesiya and P. merkusii* in Thailand (Singh, 1972). The species may be associated with these two species of pines all along their habitat and hence quite likely to occur in north-east India.

Shoot borers

Lepidoptera

Dioryctria abietella Denis and Schiffermuller (Figs. 1–7, Plate IV). The pine cone and shoot moth, *Dioryctria abietella* is a serious pest of young chir plantations in the outer Himalaya (Rehill *et al.* 1977). *D. abietella,* is a cosmopoliton pine cone, and shoot moth attacking pines all over their habitat. The moth appears on wing after mid-summer and the eggs are laid on young cones and shoots. The larva which is reddish and greenish with brown head and thoracic shield, bores in the cones and shoots to feed until autumn, characteristically ejecting considerable quantity of resin mixed with frass. It hibernates in its tunnel in winter resuming feeding in spring and pupates in May in a papery, silken cocoon either within its tunnel or else in the soil after it has left a fallen shoot or cone. The attacked shoots die, resulting in forking. Three species of *Dioryctria* has been recorded from Meghalaya (Mutuura, 1971; Bradley, 1969) so far none of these species has been recorded from exotic pines in India.

Coleoptera

Pine shoot beetle, *Tomicus khasianus* Murayama. (Figs. 12–14, Plate V).

The young beetles after emergence attack the terminal shoots of the leader and top branches of khasi pine of all ages. A tunnel is bored in the pith for 2.5 to 5 cm, hollowing out and killing the shoot which dries up and falls, causing a high mortality in the *P. kesiya* at the higher elevations in the Khasi and Jaintia Hills. This beetle has not been recorded from exotic pines from other parts of the country.

Collar and root insects

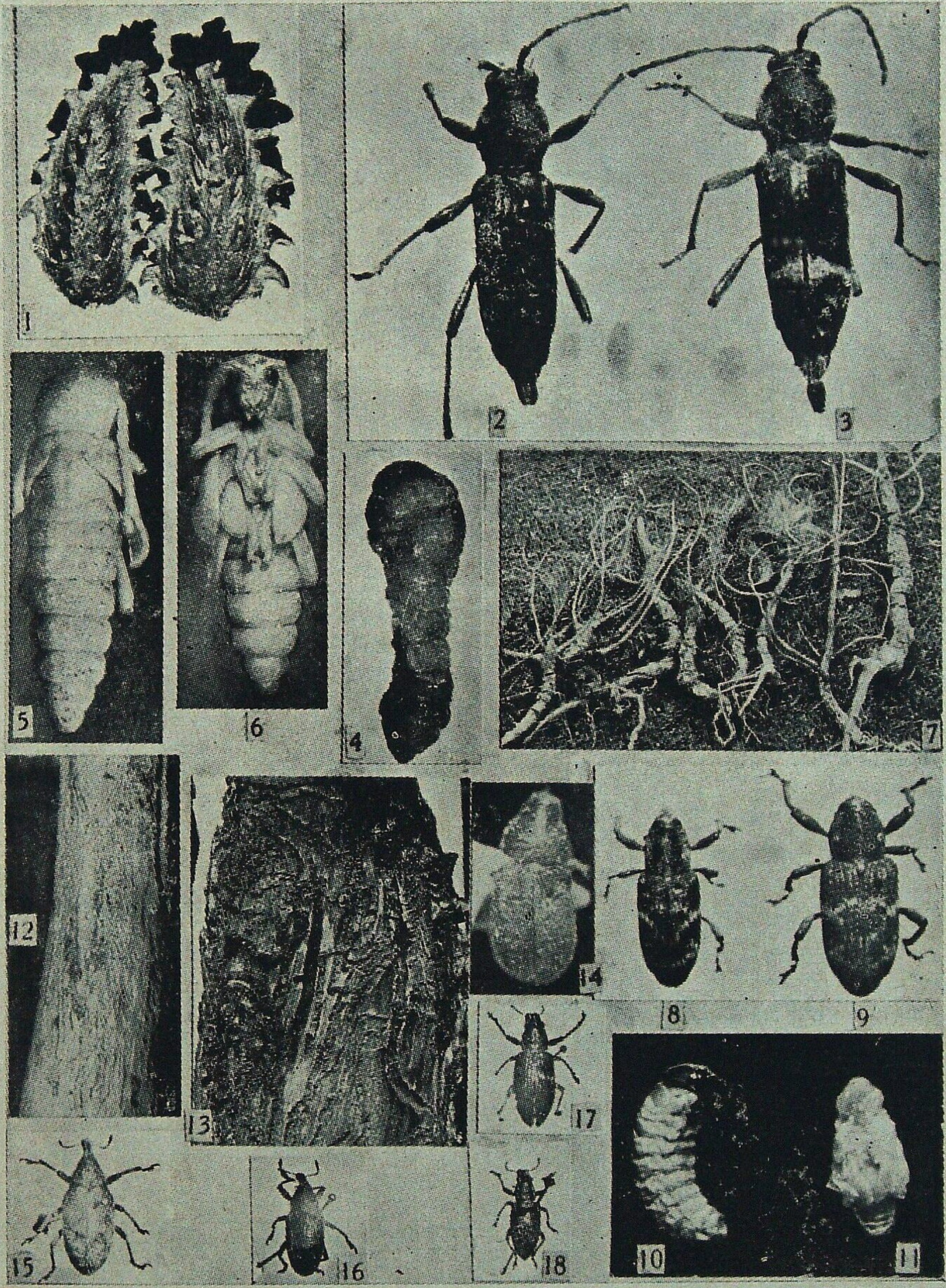
Pine Collar and Root Weevil, *Hylobius angustus* Faust (Figs. 7–11, Plate V).

H. angustus is known to cause mortality of chir pine in the outer Himalaya (Rehill, *et al.*, 1977). A survey of chir pine plantations in Kunhar forest division, Himachal Pradesh showed mortality upto 24.5% by this pest. A redish brown long snouted, weevil with transverse white markings about 12 mm long. The eggs are laid in the bark of sickly or injured saplings particularly those damaged by snow, fellings, etc. The larva tunnels under the bark near the base of the stem and also under ground in the main roots, its presence usually being betrayed by a copious flow of resin. Pupation occurs in a chamber in the outer layers of the wood of the host at or below ground level. Numerous larvae may infest one sapling, which is usually girdled and killed. The adults are active from May until July, and also injurious to the same host feeding on the tender bark of the young shoots and smaller lateral branches and often killing them by girdling. Allied species of *Hylobius abietis* is one of the most importat pests of pines in continental Europe. Pales weevil, *H. pales* is another destructive pest of pines in North America. Every care therefore should be taken so that this weevil does not gain entry in south India and Dome areas or any other area wherever pines are being introduced.

Conclusions

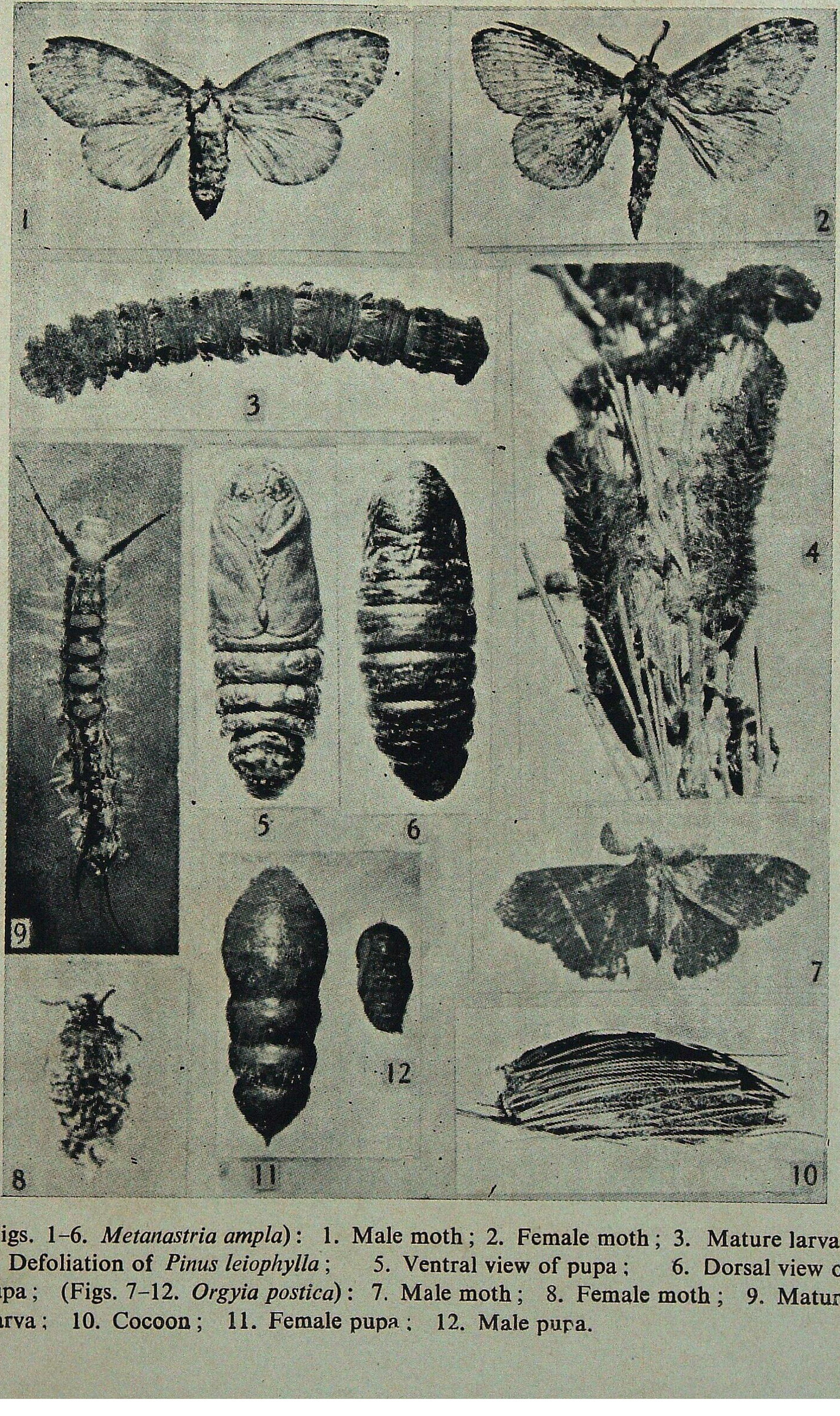
From the above account it can be seen that except for the adelgid, *Pineus laevis* and cutworm, *Agrotis ipsilon* the other insects recorded from exotic pines are only casual feeders. Most of them are primarily pests of broad leaved species. Some of them are

Plate V



(Figs. 1–6. *Chlorophorus strobilicola*) : 1. L.S. of cone of *Pinus roxburghii* damaged by larvae and beetle ; 2. Male beetle ; 3. Female beetle ; 4. Larva ; 5. Dorsal view of pupa ; 6. Ventral view of pupa ; (Figs. 7–11. Pine collar weevil, *Hylobius angustus*) : 7. Damage to collar region of *Pinus roxburghii* ; 8. Male beetle ; 9. Female beetle ; 10. Larva ; 11. Pupa; (Figs. 12–14. Pine shoot beetle, *Blastophagus khasianus*) : 12. Mother gallery ; 13. Larval gallery ; 14. Beetle ; 15. Female beetle of *Xanthochelus faunus* ; 16. Male beetle of *X. faunus* ; 17. Female beetle of *Dereodus pollinosus* ; 18. Male beetle of *D. pollinosus*.

Plate VI



(Figs. 1–6. *Metanastria ampla*): 1. Male moth; 2. Female moth; 3. Mature larva; 4. Defoliation of *Pinus leiophylla*; 5. Ventral view of pupa; 6. Dorsal view of pupa; (Figs. 7–12. *Orgyia postica*): 7. Male moth; 8. Female moth; 9. Mature Larva; 10. Cocoon; 11. Female pupa; 12. Male pupa.

potential pests as they may become serious with the passage of time as happened in Africa, Australia and New Zealand. There are many species of conifers in the north and north-east India and *Podocarpus-latifolia* in peninsular India. Insect pests of these species particularly those belonging to the genus *Pinus* can easily adapt themselves to exotic pines. Hence the need for a continued surveillance of plantations of the exotic pines for detecting of pest and evaluating their status. A greater danger lies from inadvertent introductions of insects. Fortunately for us, except for the inadvertent entry of an adelgid, *Pineus laevis*, no dangerous insect has gained entry so far into the subcontinent from their native homes of the introdused pines. Surveys conducted so far have shown that even this adelgid has not invaded the Dome area as yet. As the insect is a serious pest of tropical pines sometime killing them, all possible measures including (interregional quarantine) should be undertaken to prevent its spread from Palnis and Nilgiris (South India) to other areas. As we have our own adelgid, *Pineus simmondsi* Yaseen & Ghani on chir in north-west Himalaya and another unidentified species of *Pineus* in Khasi and Jaintia Hills, so care should also be taken that these adelgids also don't reach the areas where tropical pines are being planted elsewhere in the country. It is therefore recommended that transport of planting stock of pines from north and north-east to south India and to Dome areas (Bastar, Koraput & Araku) and to north, north-east India and to Dome areas from south India should be strictly prohibited. Simlarly *Dioryctria* spp. shoot and cone borers of pine which already exist in the Himalaya and Khasi and Jaintia Hills should not gain entry in south India and Dome areas. *Eterusia pulchella* is a serious defoliator of Khasi pines in Meghalaya and should therefore be prevented from gaining entry in new pine areas.

Because disease and insect pests are not found when the exotic is first introduced in the new habitat it is assumed by many that they will never show up to do harm. The unpleasent truth is that the indigenous pest will eventually and surely adapt to new hosts. Pest from native home of exotic will gain entry in their new home sooner or later. The inevitable outcome will be a serious reduction of the productive potential of the introduced species. *Radiata* pine, despite its performance and continued promise can also serve as a prime example of the vulnerability of the large scale exotic introduction. In New Zealand and Australia an insect *Sirex* (and a needle fungus *Dothistroma*) are constant threats to planted *Radiata* Pine. Formerly considered inocuous this insect is now causing serious plantation losses, killing and damaging trees. In India too, the introduction of an adelgid, *Pineus laevis* (and the fungus *Dothistroma*) has largely contributed to the failure of *Pinus radiata* in peninsular India.

'Abundant experience has demonstrated that it is not possible to plant hundreds and thousands of hectares of an exotic in a massive monoculture pattern without ultimately having pests coming in to cause a catastrophy. It seems safe to predict now that no exotic will enjoy complete freedom from pests indefinitely, no matter how safe it appears to be initially and regardless of the stringency of quarantine that may be in effect. It is regrettable that so frequently the pest free condition initially enjoyed by an exotic lull so many foresters into a state of complacency so that they neglect or ignore adequate plans for alternate species or for control measures when the moment of truth concerning vulnerability of exotic to pests hits them', (Zobel, 1972).

Table 1

Insect Pests of Exotic Pines in India

Insect Pests		Pinus Species attacked	Damage	Status	Distribution
Order / Family	Species				
1	2	3	4	5	6
		Nursery pests			
Lepidoptera					
Noctuidae	*Agrotis ipsilon* Hufnagel.	*caribaea, patula, radiata.*	Larva cuts the seedlings at ground level & defoliates.	Serious pest	Punjab. U.P. (throughout India).
	Heliothis armigera Hubner.	*caribaea*	Larva defoliates & binds the needles.	Potential pest	Oosri Nursery (Jagdalpur, M.P.)
Tortricidae	Unidentified	*patula*	Larva defoliates & binds the needles.	Casual feeder	New Forest, Dehra Dun
Coleoptera					
Scarabaedae					
Rutelinae	*Anomala rufiventris* Redtenbacher.	*caribaea, patula, greggii, oocarpa, kesiya, roxburghii.*	Larva damages the seedlings by cutting the roots.	-do-	North India
Melolonthinae	*Granida albosparsa* Moser.	*caribaea, patula, greggii, oocarpa, kesiya. roxburghii.*	-do-	-do-	-do-
	Hilyotrogus holosericea Redtenbacher.	*caribaea, patula, greggii, oocarpa, kesiya, roxburghii.*	-do-	-do-	-do-
Rutelinae	*Mimela mundissima* Wlk.	*caribaea, patula, greggii, oocarpa, kesiya, roxburghii.*	-do-	-do-	-do-
Orthoptera					
Acrididae	*Caloptenopsis* sp.	*caribaea, kesiya, roxburghii, oocarpa.*	Adults & hoppers defoliate.	-do-	New Forest (Dehra Dun), Jagdalpur, (M.P.)
	Catantops indicus Saussure.	*caribaea, kesiya, roxburghii, oocarpa.*	-do-	-do-	-do-
	Chrotogonus sp.	*caribaea, kesiya, roxburghii, oocarpa.*	-do-	-do-	-do-

(*Contd.*)

Table 1 (*Contd.*)

1	2	3	4	5	6
	Oxya velox Fab.	*kesiya, roxburghii, oocarpa.*	-do-	-do-	-do-
Isoptera					
Termitidae	*Odontotermes obesus* Rambur	*caribaea, patula, kesyia.*	Damages the roots.	Moderate	Jagdalpur (M.P.)
Aves					
Birds		*caribaea, patula, radiata.*	Damages the seeds and seedlings.	Casual feeders	New Forest (Dehra Dun)
Mammals					
Rodentia	*Funambulus pennanti* Wroughton.	*caribaea, patula.*	Damages the freshly sown, seeds	-do-	-do-
	Mus booduga (Gray)	*caribaea, patula.*	-do-	-do-	-do-
		Plantation pests			
Lepidoptera					
Arctiidae		*caribaea, greggii, patula.*	Larva defoliates.	-do-	North India
Geometridae	*Ectropis inceptaria* Walk.	*caribaea, greggii, patula.*	-do-	-do-	-do-
Lasiocampiidae	*Metanstria ampla* Wlk.	*caribaea, kesiya, roxburghii.*	-do-	Potential pest	North-east India
	M. grisea Moore.	*caribaea, kesiya, roxburghii.*	-do-	-do-	-do-
Lymantriidae	*Orgyia postica* Wlk.	*caribaea, patula, kesiya, greggii, elliottii.*	-do-	-do-	New Forest Dehra Dun
Noctuidae		*patula, greggii.*	-do-	-do-	-do-
Pyralidae	*Dichocrocis punctiferalis* Guenee.	*kesiya.*	-do-	Serious pest	Tehri Garhwal (U.P.), Simala, Khasi Hills, Assam.
	Dioryctria abietella Schiff.	*kesiya, roxburghii.*	Larva bores in shoots & cones	-do-	Dehra Dun (U.P.), Simla, Assam.
	D. assamensis Mutuura.	*kesiya.*	Shoot borer.	-do-	Shillong (Assam)

(*Contd.*)

Table 1 (*Contd.*)

1	2	3	4	5	6
	D. castania Bradley	*kesiya.*	Shoot borer	Serious pest	Shillong (Assam)
	D. raoi Mutuura.	*kesiya.*	-do-	-do-	-do-
Psychidae	*Cryptothelea crameri* Westwood.	*kesiya, roxburghii*	Larva defoliates	Potential pest	North-east India
	Sp. 1	*caribaea*	-do-	-do-	Madhya Pradesh
	Sp. 2	*caribaea*	-do-	-do-	-do-
	Sp. 3	*caribaea*	-do-	-do-	-do-
	Sp. 4	*caribaea*	-do-	-do-	Andhra Pradesh
Tortricidae		*greggii*	-do-	-do-	Dehra Dun (U.P.)
Zygaenidae	*Eterusia pulchella* Koll.	*kesiya*	-do-	Serious pest	Khasi & Jaintia hills (Meghalaya)
Coleoptera					
Chrysomelidae	*Aetheomorpha nigropicta* Lefebre.	*roxburghii*	Beetle gnaws the needles.	Casual feeder	North India
	Aphthona nigrilabris Duivier	*roxburghii*	Beetle & Larva defoliates.	-do-	-do-
	Colasposoma semicostatum Jacoby.	*roxburghii*	Beetle gnaws the needles.	-do-	-do-
	Gallerucida rutilans Hope.	*roxburghii*	-do-	-do-	-do-
	Hoplosoma sexmaculata Hope.	*roxburghii*	-do-	-do-	North India
	Nodina Sp.	*roxburghii*	-do-	-do-	-do-
	N. crassipes Jacoby.	*roxburghii*	-do-	-do-	-do-
Curculiniodae	*Hylobius angustus* Faust.	*roxburghii*	Beetles feeds on the young shoots and girdles them. larva bores the roots and the collar.	Serious pest	North-west India
	Dereodus pollinosus Redt.	*greggii, patula, roxburghii, taeda.*	Adult defoliates.	Potential pest	Almora (U.P.)

(*Contd.*)

Table 1 (*Contd.*)

1	2	3	4	5	6
	Xanthochelus faunus Oiiv.	*greggii, patula, roxburghii, taeda.*	–do–	–do–	–do–
Cerambycidae	*Chlorophorus strobilicola* Champion.	*roxburghii*	Larva & Beetle borer the cone.	Casual feeder	North India
Scarabaeidae	*Melolontha* spp.	*roxburghii.*	–do–	–do–	do–
	Adoretus spp.	*roxburghii.*	–do–	–do–	–do–
	Anomala spp.	*roxburghii.*	–do–	–do–	–do–
Scolytidae	*Tomicus khasianus* Murayama	*roxburghii.*	–do–	–do–	–do–
Hemiptera					
Adelgidae	*Pineus laevis* Maskell.	*radiata, kesiya, oocarpa, montezumae.*	Nymphs & adults suck the sap causing death of terminal bud leading to malformation, stunting and death of tree.	Serious pest	Top slip, Udagamandalam Kodaikanal (Tamil Nadu & Kerala).
	P. simmondsi Yaseen and Ghani.	*kesiya, roxburghii.*	–do–	–do–	North-west Himalayas. Meghahalya.
Coccidae	*Ripersia resinophila* Green.	*kesiya, roxburghii.*	Nymphs & adults suck the sap of needles.	Casual feeder	–do–
	Chionaspis chir Gree.	*caribaea, roxburghii, greggii.*	–do–	–do–	Kumaon, Dehra Dun, (U.P.) North India.
Hymenoptera					
Tenthredinidae	*Athalia nigromaculata Sikkimensis* Beeson.	*roxburghii.*	Larva defoliates.	–do–	Himalayas
Isoptera					
Termitidae	*Odontotermes obesus* Rambur.	*caribaea, patula, kesiya.*	Damage the roots.	–do–	U.P., M.P., A.P.

SUMMARY

Exotic pines are being planted on a large scale in the country. With all exotics we face problems from indigenous and introduced pests. By and large except for pine adelgid which got inadvertently introduced into the country sometime back, the exotic pines have no insect pest problems. The other insects recorded from them are casual feeders only. Most of them belong to the order Lepidoptera with lesser numbers in Coleoptera, Hemiptera, Orthoptera, Hymenoptera and Isoptera. Majority of them are defoliators. All of them are potential pests. To check further spread of the pine adelgid no vegetative material should be transported from one region to another. With the passage of time indigenous insects will adapt themselves to their new hosts or insects from their native homes are likely to gain entry in their new homes. Therefore, continued surveillance is necessary for detection of new pest introductions and pest build-up. Relatively insect free conditions of pines today should not lull foresters to complacency so that they neglect plans for alternate species or for control measures when pest build-up takes place.

भारत में विदेशी चीड़ों के नाशिकीट

लेखक प्रतापसिंह, मसरंत फसीह व गंगा प्रसाद

सारांश

भारत में विदेशी चीड़ बड़े पैमाने पर लगाए जा रहे हैं। सभी विदेशी पादपों के साथ हमें देशी तथा बहार से आये हुए नाशिकीटों की समस्याओं का सामना करना पड़ता है। मोटे तौर पर चीड़ एडिलगिड को छोड़कर जो कुछ समय हुए देश में असावधानी से चला आया, विदेशी चीड़ों के साथ नाशिकीट समस्याएं नहीं हैं। उनपर मिले जिन अन्य कीड़ों का उल्लेख किया गया है वे केवल कभी-कभार उनसे भोजन प्राप्त कर लेते हैं। उनमें से अधिकांश लेपिडोप्टेरा (शल्कीपक्षा :) गण के हैं और उनमे कम संख्या में कोलियोप्टेरा (कंचुकपक्षा :), हेमिप्टेरा (मत्कुणा :) आर्थोप्टेरा (ऋजुपक्षा :), हाईमैनोप्टेरा (कलापक्षा :) और आइसोप्टेरा (वल्मा :) गण में आते हैं। अधिकांश कीड़े निष्पत्रक हैं। सभी की नाशिकीट बनने की संभावनाएं हैं। चीड़ एडेलगिड की और फैलने की आशंका दूर करने के लिए एक क्षेत्र से दूसरे क्षेत्र में वनस्पति पदार्थ नहीं भेजा जाना चाहिए। कालान्तर में देशी कीड़े अपने इन नए पोषियों को भी अपना लेंगे अथवा उनके मूल देश के कीड़े इनके नए देशों में भी प्रवेश पा जाएंगे। इसलिए नए नाशिकीटों का प्रविष्ट होना अथवा उनकी संख्या बढ़ना जांचने के लिए निरन्तर चौकसी करते रहने की आवश्यकता हैं। चीड़ों की वर्तमान कीट मुक्त अवस्था से वानिकों को प्रसन्न होकर शांत नहीं हो जाना चाहिए और न वैकल्पिक जातियों की खोज अथवा नाशिकीटों की संख्या वृद्धि होने पर उनका नियन्त्रण करने के उपायों के प्रति लापरवाही बरतनी चाहिए।

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LIST OF ACKNOWLEDGEMENT OF BOOKS & PERIODICALS

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1. Myforest, Bangalore, Vol. 17, No. 3.
2. ISI Bulletin, New Delhi, Vol. 33, No. 8 & 9.
3. The Conservationist, Albany, Vol. 36, No. 1.
4. Journal of Scientific Research in Plants & Medicines. Gurukul Kangri (Hardwar), Vol. 2, No. 2.
5. Social Science in Forestry, Virginia, No. 56, Oct., 1981.
6. Forest Products Journal, Madison, Vol. 31, No. 5 & 7.
7. Forestry, London, Vol. 54, No. 1.
8. Wood Science, Madison, Vol. 13, No. 4.
9. Journal of Forestry, Washington Vol. 79, No. 6 & 7.
10. Unasylva, Rome, Vol. 32, No. 128, 129 & 130.
11. Parks, Michigan, Vol. 6, No. 1 & 2.
12. Bois et Forets Des Tropiques. Nogent-Sur-Marne (France), No. 191 (1980).
13. Revue Forestier Francaise. Nancy, Vol. XXXII, No. 5.
14. Memories, Zurich, Vol. 57, No. 1.
15. Commonwealth Forestry Review, Oxford, Vol 60, No. 184.
16. Scottish Forestry, Edinburgh, Vol. 35, No. 3.
17. Ouarterly Journal of Forestry, Northanland, Vol. I XXV, No. 3.

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GAZETTE NOTIFICATIONS

F.R.I. GAZETTE

After availing three days Earned leave from 4.5.81 to 6.5.81, the resignation of his appointment as Librarian, F.R.I. and Colleges, tendered by Shri R.V. Prased was accepted by the President, F.R.I. & Colleges, Dehra Dun, w.e.f. the afternoon of 6th May, 1981.

BIHAR GAZETTE

(1) Shri P. Mishra, I.F.S., Managing Director, Bihar State Forest Development Corporation, Patna is promoted and posted to the newly created post of Chief Conservator of Forests, State Trading. His headquarters will be at Ranchi.

(2) Shri R.C. Prasad, I.F.S., Additional Chief Conservator of Forests (Development), Ranchi is transferred and posted as Managing Director, Bihar State Forest Development Corporation at Patna.

(3) Shri R.N. Kapoor, I.F.S., Additional Chief Conservator of Forests, (Minor Forest Produce) is posted as Additional Chief Conservator of Forests (Development) at Ranchi.

(4) Shri R. Prasada, I.F.S., Conservator of Forests, Southern Circle, Chaibassa is promoted and posted as Additional Chief Conservator of Forests, (Minor Forest Produce) with headquarters at Ranchi.

(5) Shri S.N. Banerjee, I.F.S., Conservator of Forests, Western Circle, Daltonganj is transferred and posted as Conservator of Forests, State Trading, Ranchi Circle, with headquarters at Ranchi.

(6) Shri D.P. Sinha I.F.S., Conservator of Forests, Working Plans and Research Circle, Ranchi is transferred and posted as Conservator of Forests, Western Circle with headquarters at Daltonganj.

(7) Shri J.P. Sinha, I.F.S., Conservator of Forests Hazaribagh is transferred and posted as Conservator of Forests, Working plans & Research Circle with headquarters at Ranchi.

(8) Shri D. Sinha, I.F.S., Conservator of Forests & Project Director in Bihar State Forest Development Corporation at Chaibassa is transferred and posted as Conservator of Forests State Trading, Palamau Circle with headquarters at Daltonganj.

The following Deputy Conservators of Forests are promoted to the rank of Conservators of Forests and are posted as follows :

1. Shri B.C. Jha, I.F.S., as Conservator of Forests, Hazaribagh.
2. Shri Om Kumar I.F.S., as Conservator of Forests (Headquarters) in the office of the Chief Conservator of Forests (Bihar) at Ranchi.
3. Shri M.K. Sinha, I.F.S., as Conservator of Forests, State Trading, Palamau Circle II, Daltonganj.
4. Shri N.P. Sinha, I.F.S., as Conservator of Forests, State Trading, Singhbhum Circle at Chaibassa.
5. Shri P.B. Diwana, I.F.S., as Conservator of Forests, State Trading, Dhalbhum Circle at Jamshedpur.

KARNATAKA GAZETTE

The services of Shri P.J. Dilipkumar, Indian Forest Service, Officer of Karnataka Cadre are placed with immediate effect and until further orders at the disposal of Government of India for being appointed as Instructor, State Forest Service College, Dehra Dun.

Shri M.L. Ramaprakash, I.F.S., Deputy Conservator of Forests, Madikeri Division, Madikeri is appointed with immediate effect and until further orders as Silviculturist, Central Zone, Bangalore vice Shri A.N. Yellappa Reddy, I.F.S., transferred.

Shri A.N. Yellappa Reddy, I.F.S., Silviculturist, Central Zone, Bangalore is appointed with immediate effect and until further orders as Deputy Conservator of Forests, Madikeri Division, Madikeri vice Shri M.L. Ramaprakash, I.F.S., transferred.

WEST BENGAL GAZETTE

The Governor is pleased to appoint the followings, until further orders:

Shri, P. Guhathakurta, I.F.S., Conservator of Forests, Wild Life Circle holding in addition the charge of Conservator of Forests, Development Circle, as Conservator of Forests, Soil Conservation Circle, with effect from the date of his assuming charge vice Shri S.N. Misra I.F.S.

Shri M.K. Chowdhury, I.F.S., Divisional Forest Officer, Planning & Statistical Cell, as Conservator of Forests, Wild Life Circle, on a temporary basis, with effect from the date of his assuming charge vice Shri P. Guhathakurta, I.F.S.

Shri A. Bose, I.F.S., Deputy Conservator of Forests, Monitoring & Evaluation Cell (Social Forestry), as Conservator of Forests, Development Circle, on a temporary basis, with effect from the date of his assuming charge, vice Shri P. Guhathakurta, I.F.S.

Shri R.C. Ghosh, I.F.S., Additional Chief Conservator of Forests, (Social Forestry), West Bengal, as Additional Chief Conservator of Forests, West Bengal, with effect from the date of his assuming charge.

Shri S.N. Misra, I.F.S., Conservator of Forests, Soil Conservation Circle, as Additional Chief Conservator of Forests, (Social Forestry), West Bengal, on a temporary basis, with effect from the date of his assuming charge vice Shri R.C. Ghosh, I.F.S.

Shri, S. Palit, I.F.S., Divisional Forest Officer, Silvicultural Division (North) as Divisional Forest Officer, Planning & Statistical Cell, with effect from the date of his assuming charge vice Shri M.K. Chowdhury, I.F.S.

Shri A.K. Lahiri, I.F.S. (on leave), as Divisional Forest Officer, Silvicultural Division (North), with effect from the date of his assuming charge vice Shri S. Palit, I.F.S.

FRI Publications

FOREST RESEARCH INSTITUTE AND COLLEGES, DEHRA DUN

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Vol. 2, No. 1—*Statistical*: "SILVOMETRICS" (Studying the growth dynamics of a stand of trees) by K.R. Satyamurthi. PFRI. 108. II. 1. Rs. 50.50 or £ 5.89 or $ 18.18

Vol. 4 No. 1—*Timber Mechanics*: Physical and Mechanical Properties of some Assam timbers, by S.N. Sanyal & K.S. Gaharwar. PFRI. 178. IV. 1. Rs. 9.75 or £ 1.14 or $ 3.51.

Indian Forest Bulletins

No 274 —*Wood Seasoning*: Commercial trails on a 7.1 m³ Solar kiln, by S.N. Sharma, Prem Nath and S.P. Badoni. PFRI. 14.274.

Other Publications

Troup's—The Silviculture of Indian Trees, Vol. II—Dipterocarpaceae, Revised and Enlarged by H.B. Joshi. PFRI. 170. Rs. 41.50 or £ 4.85 or $ 14.95

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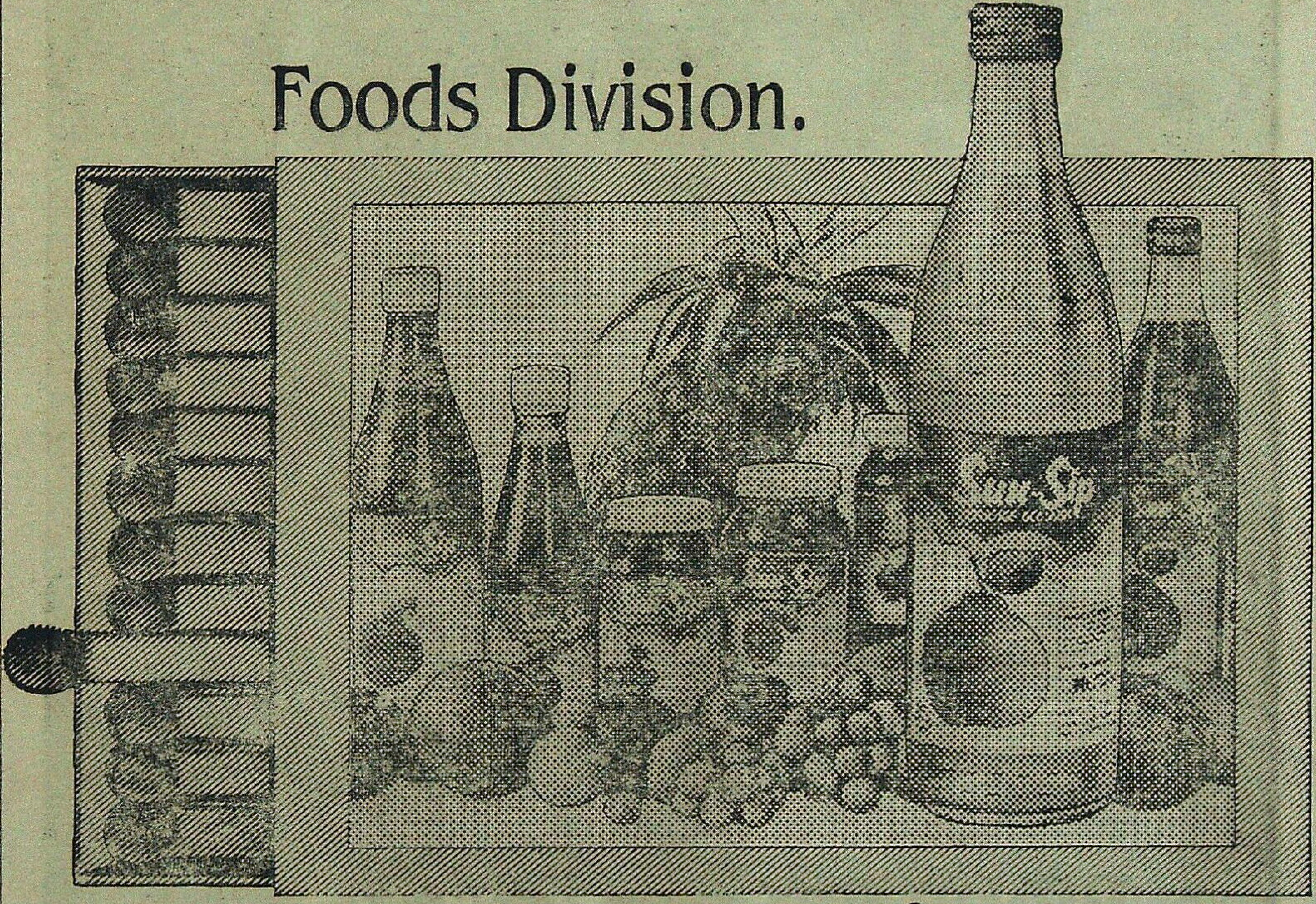

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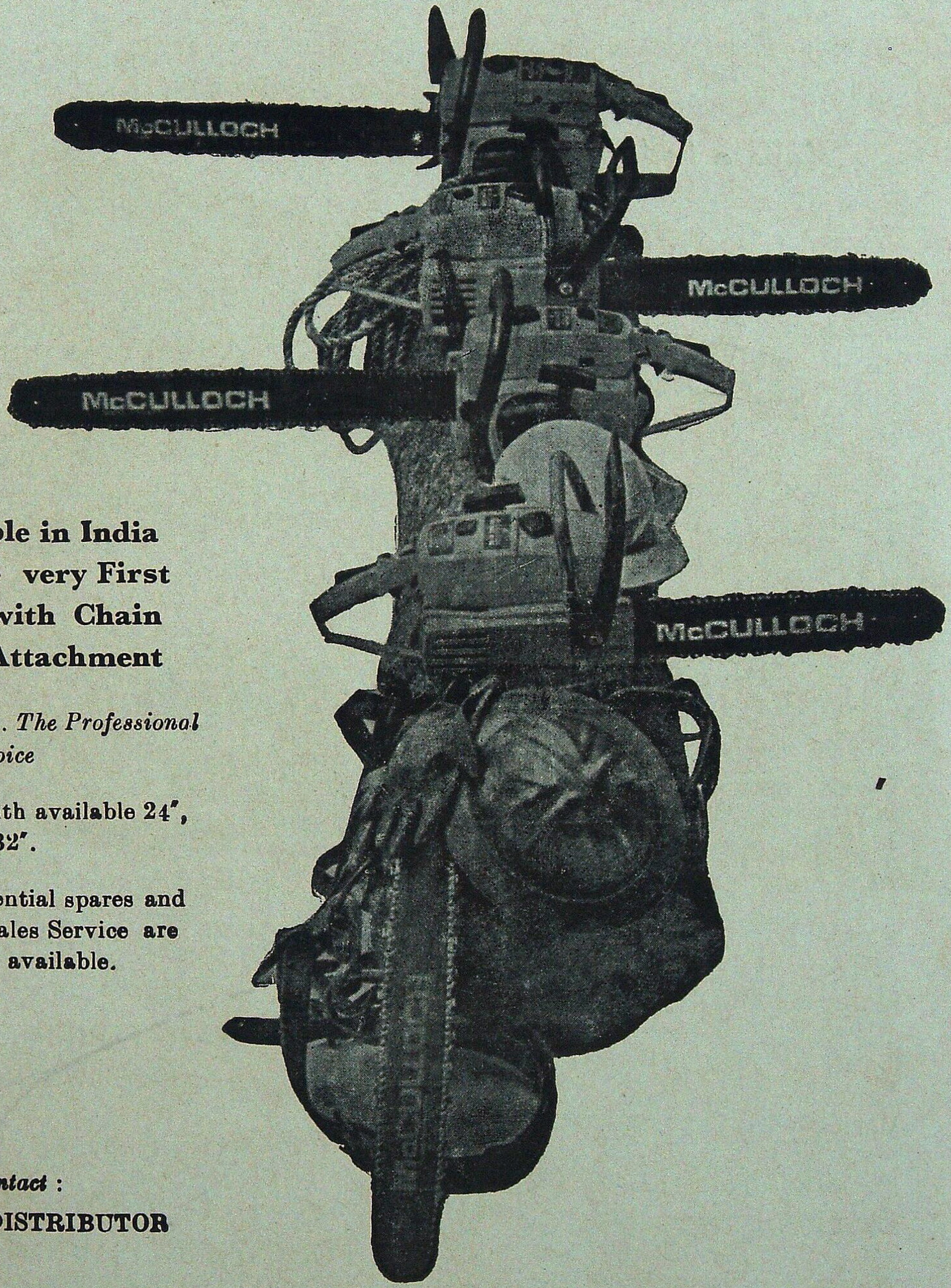

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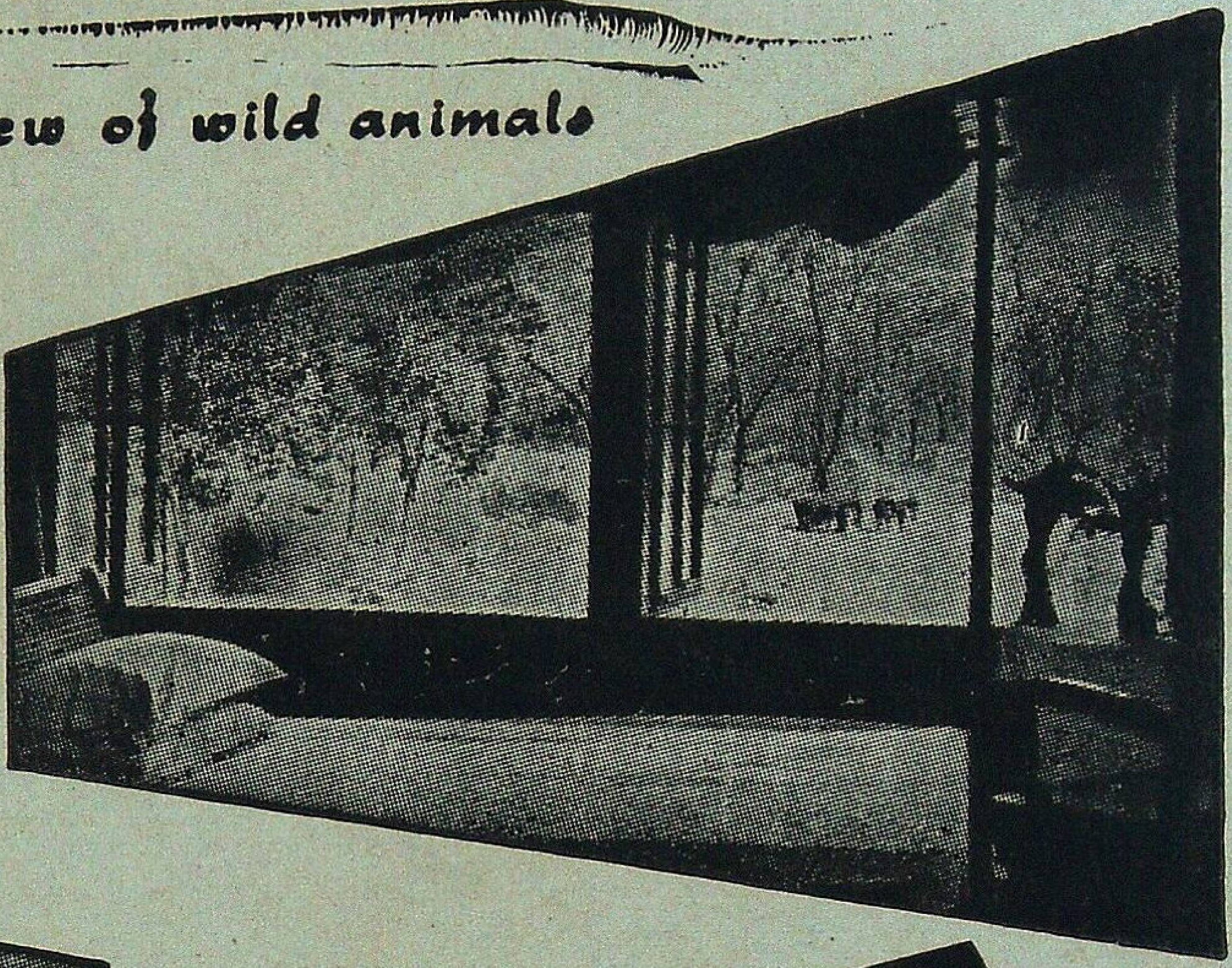

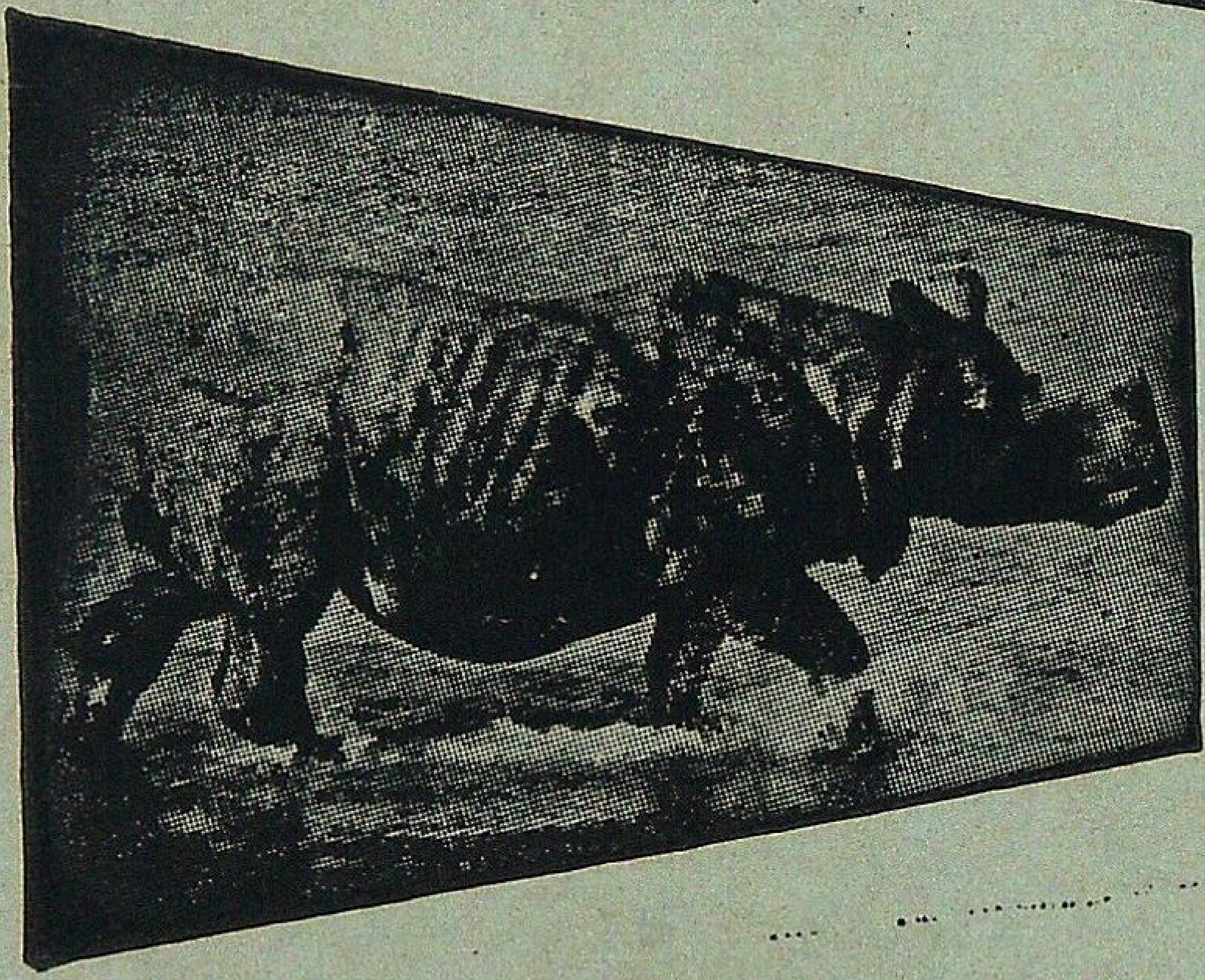

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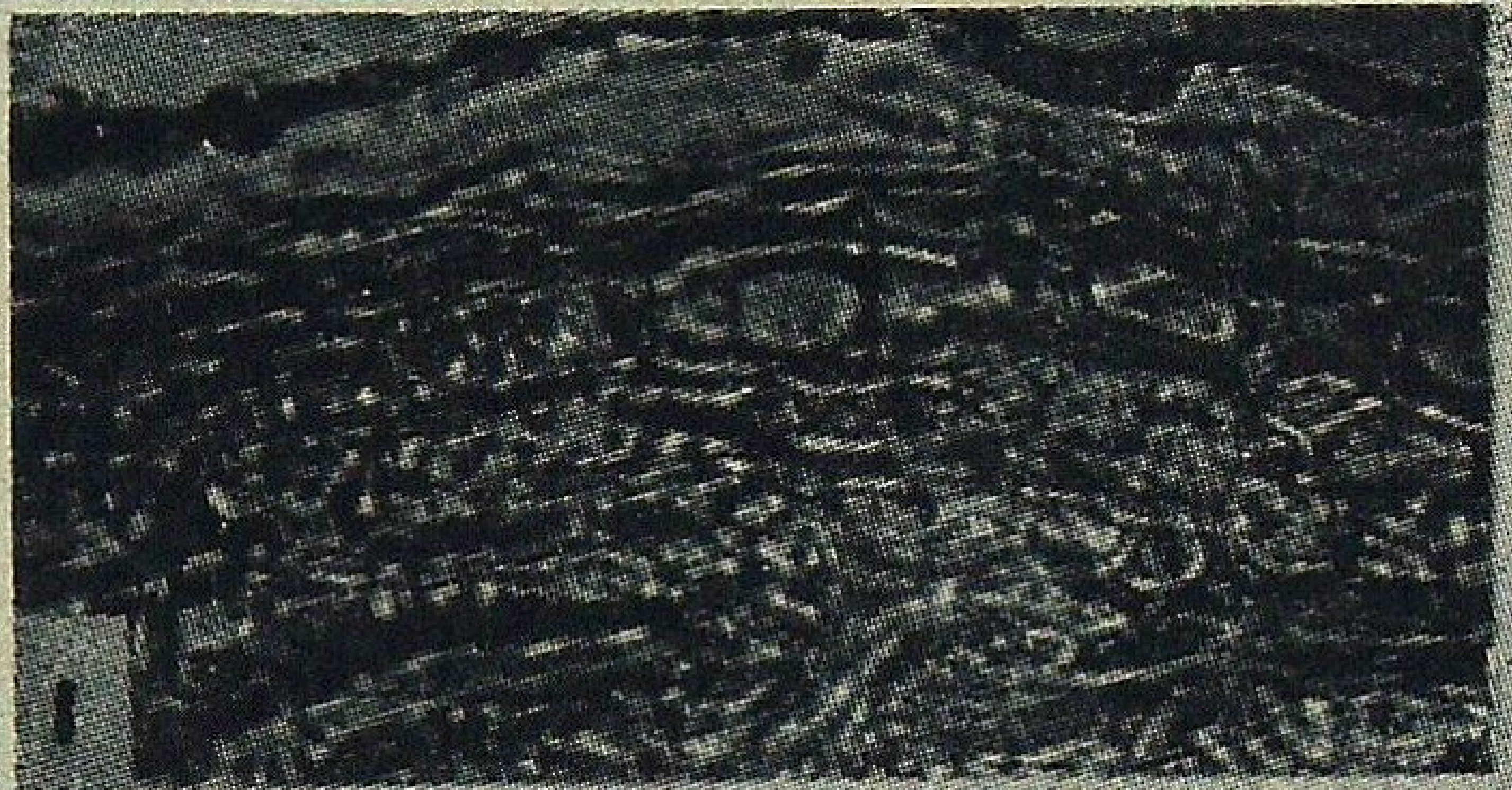
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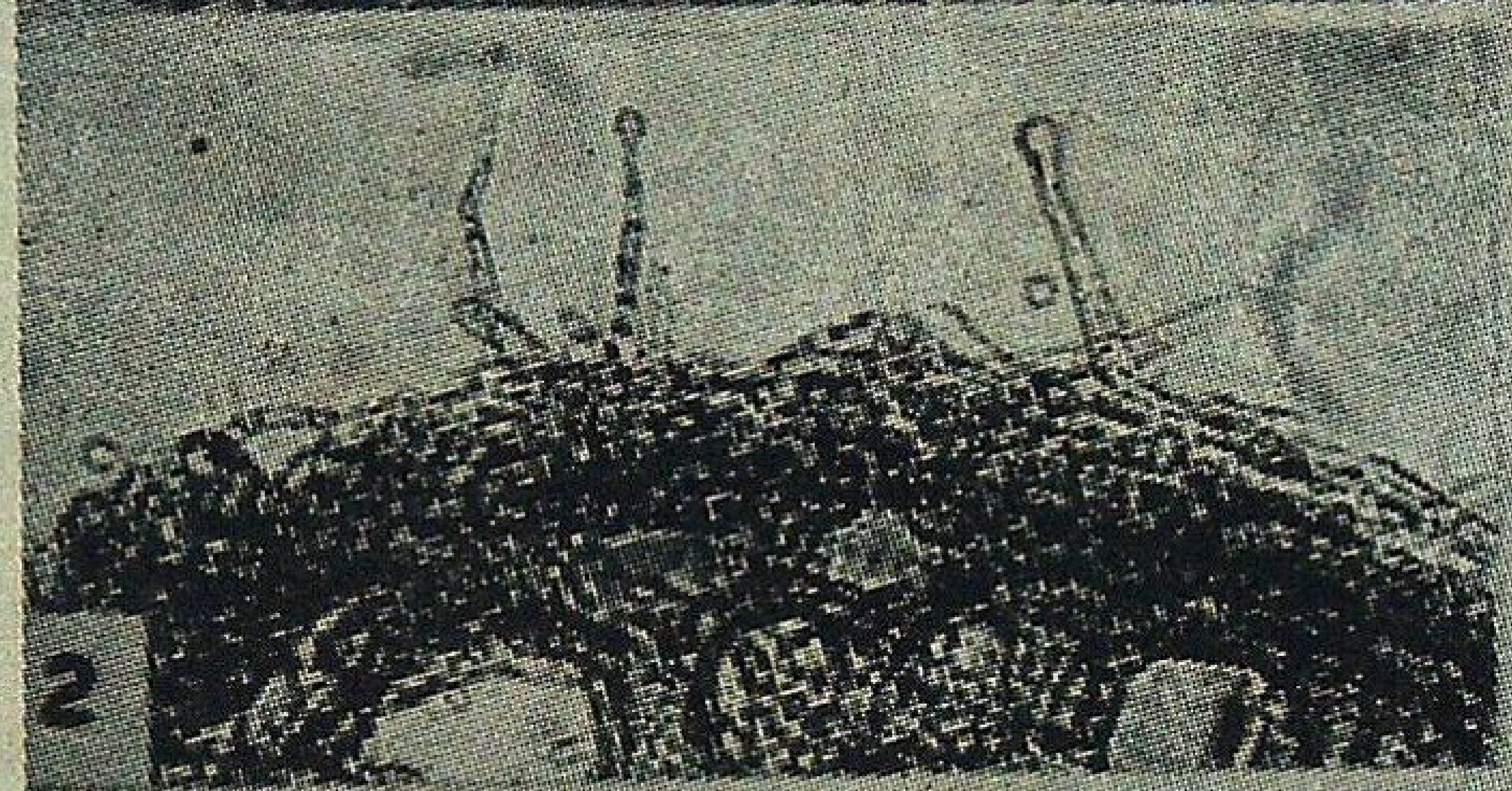
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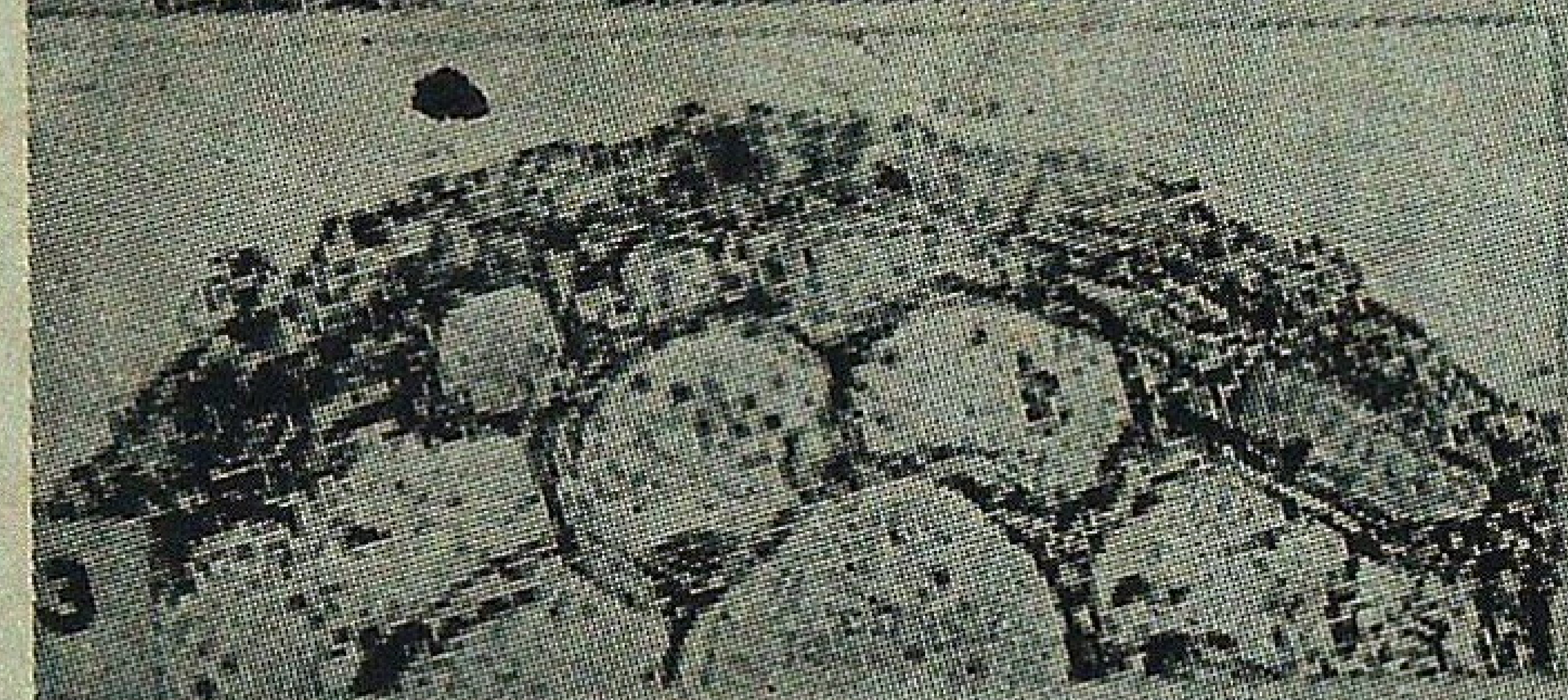
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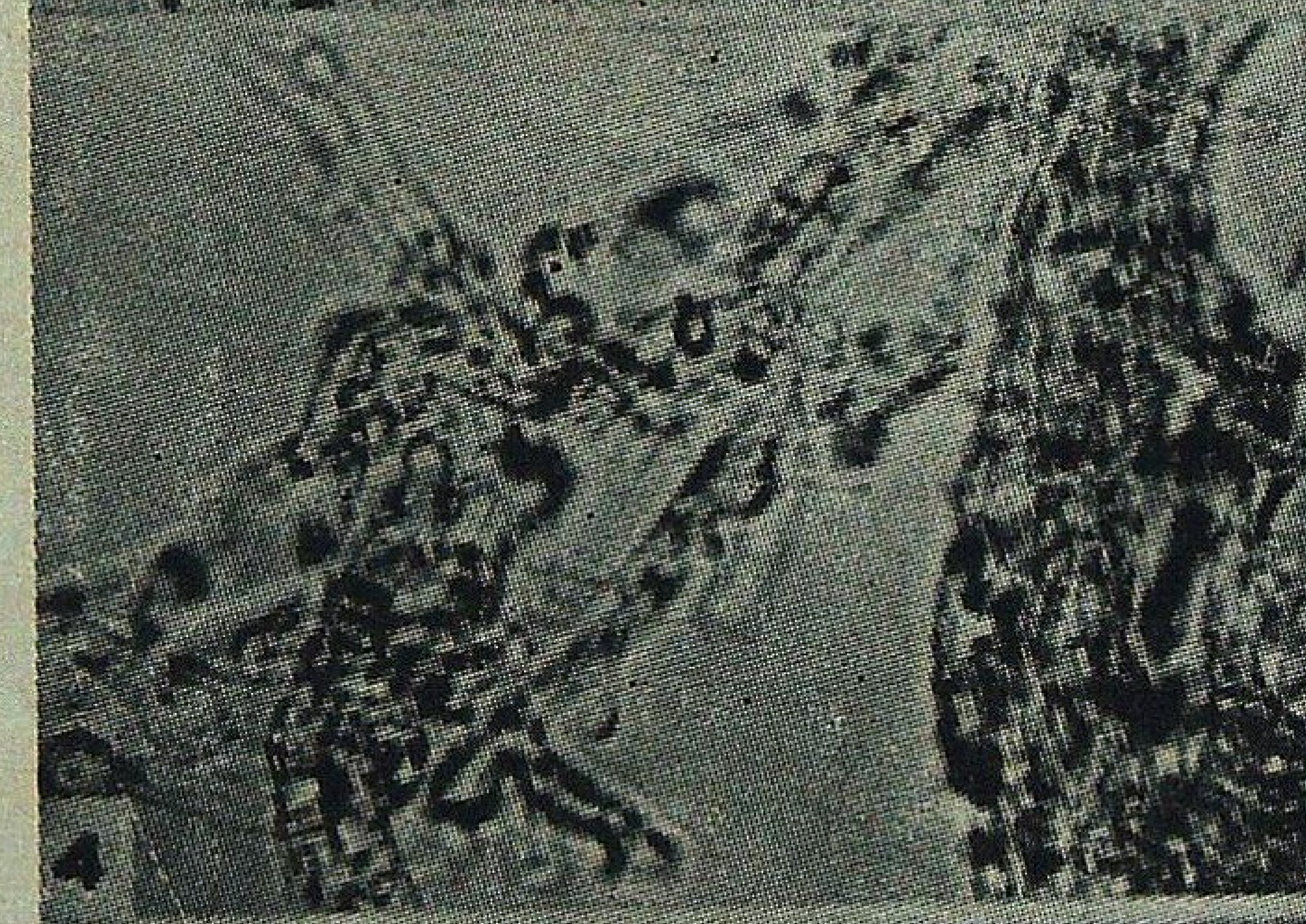
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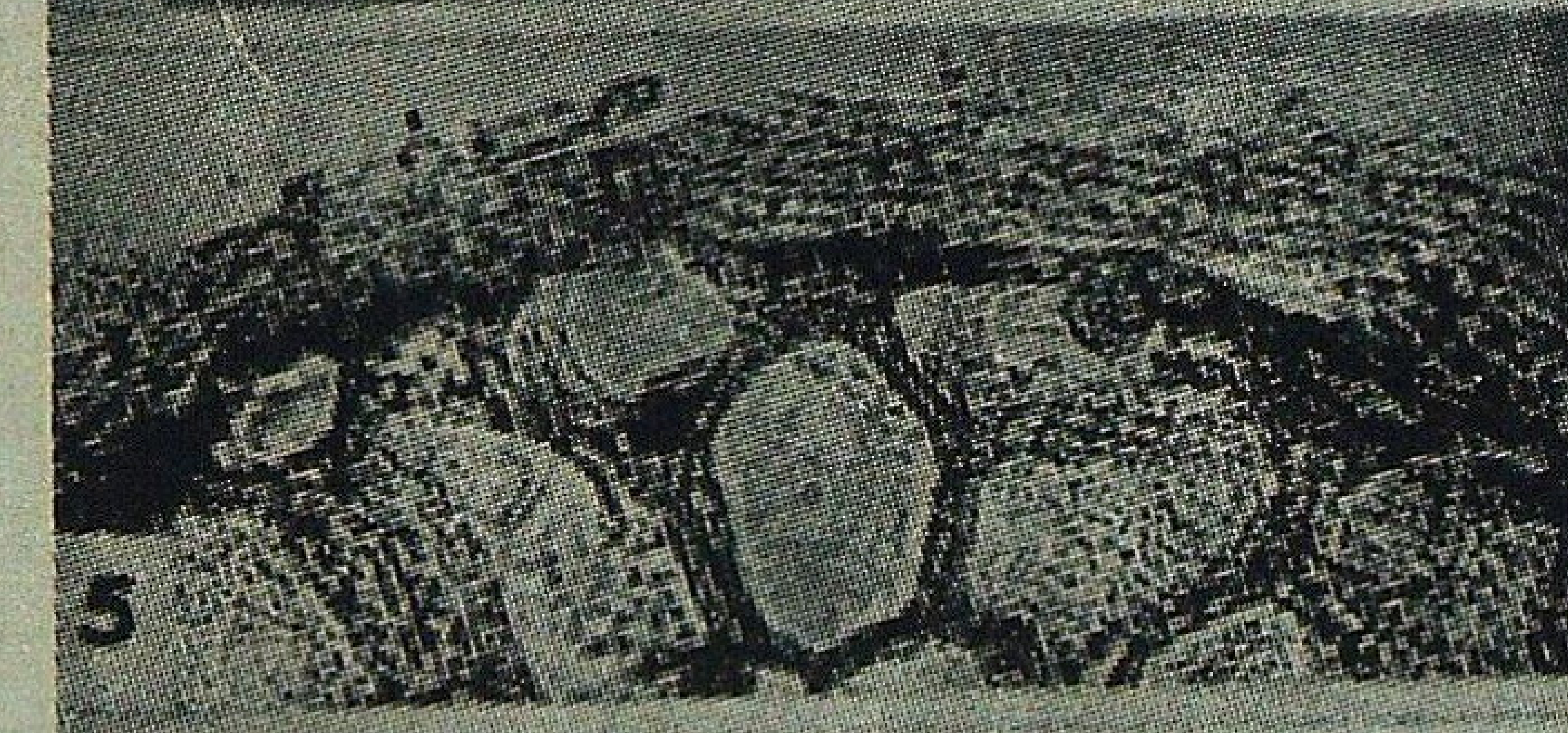
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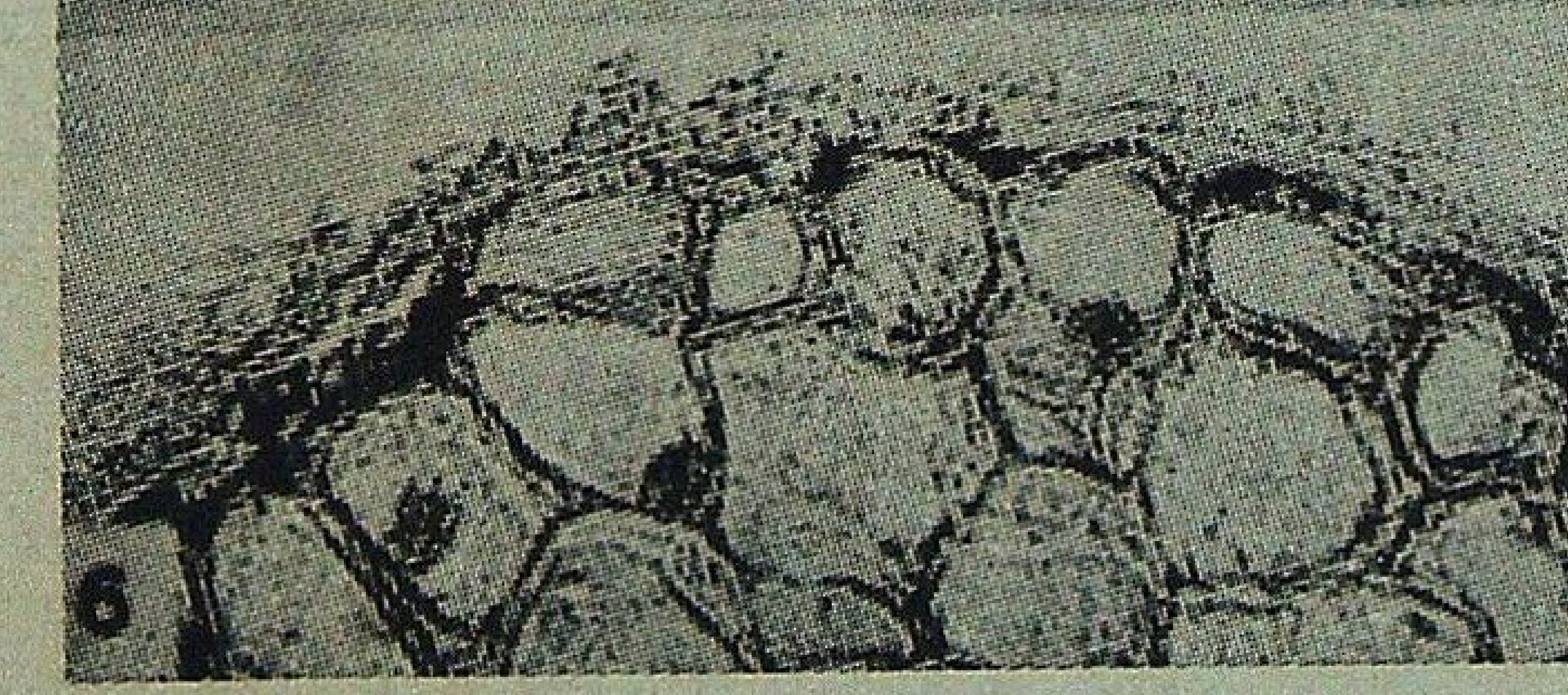
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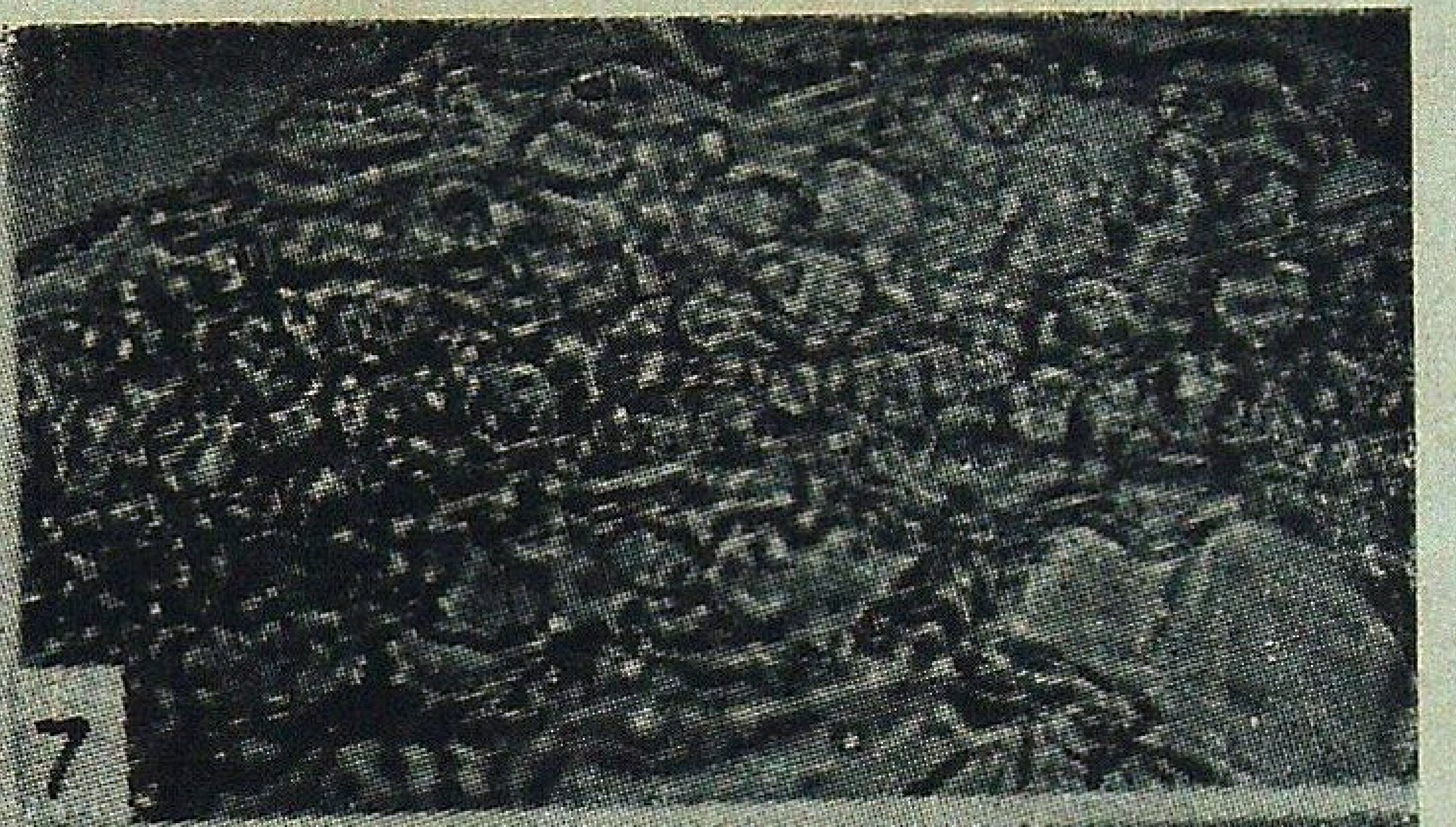
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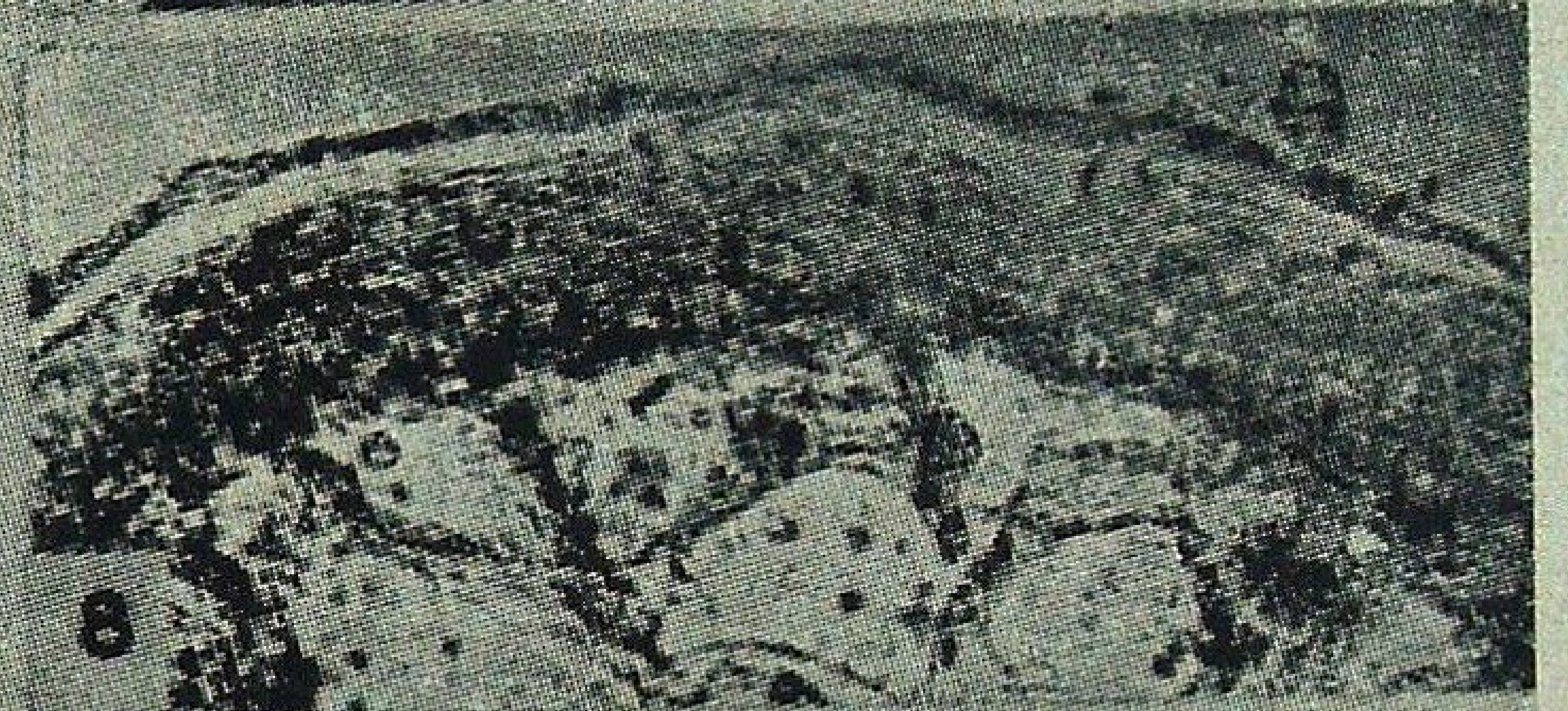
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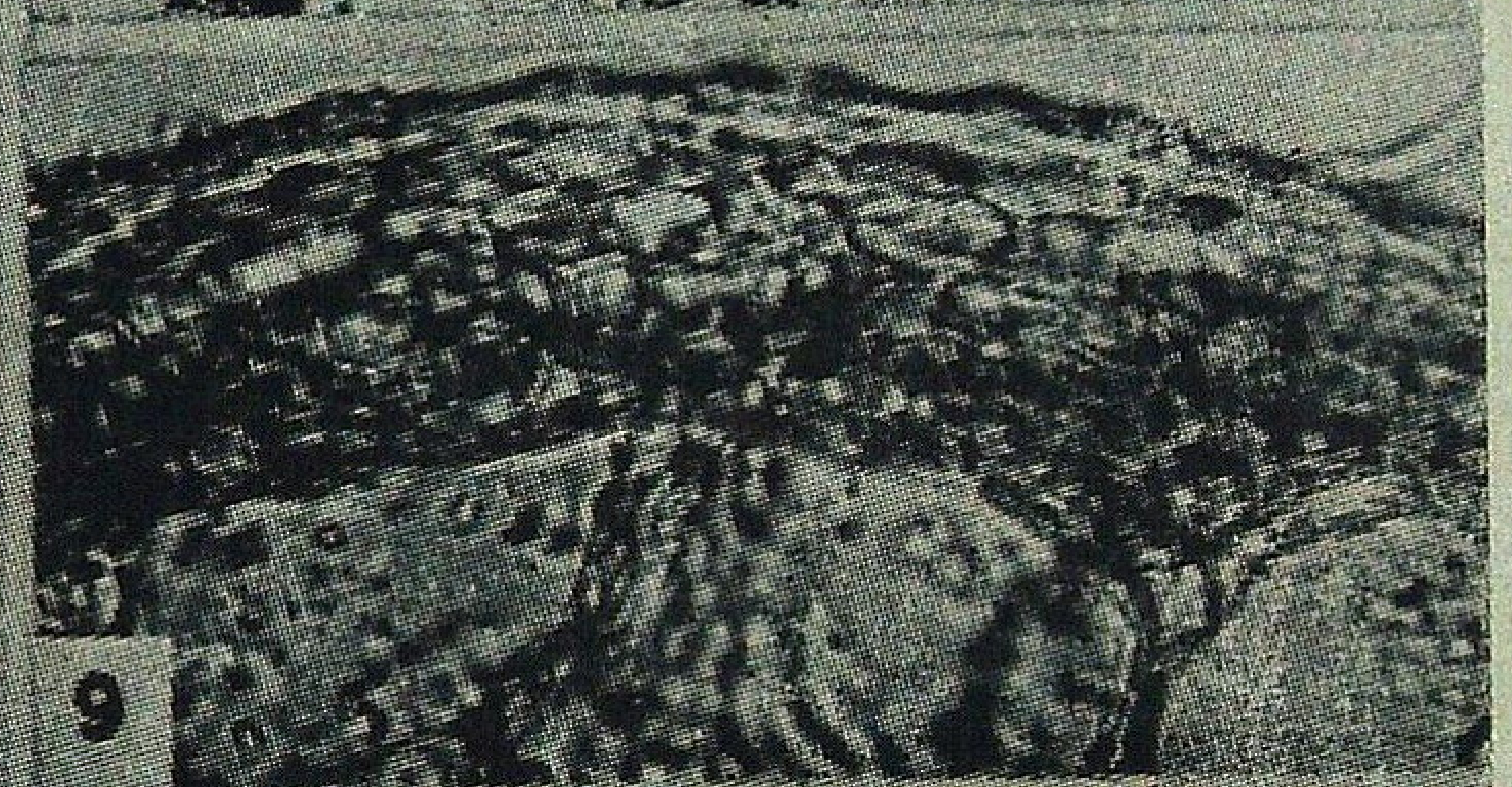
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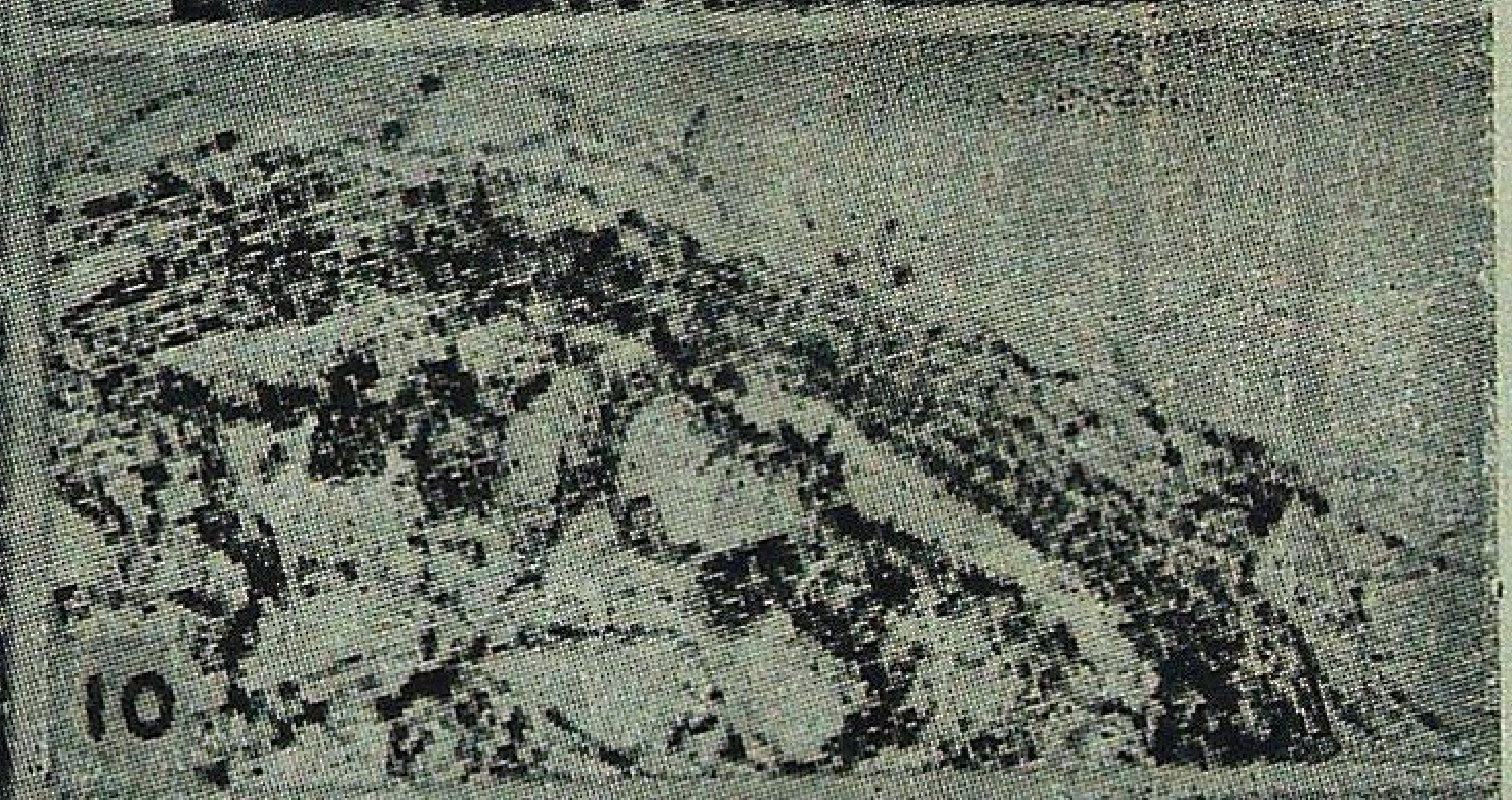
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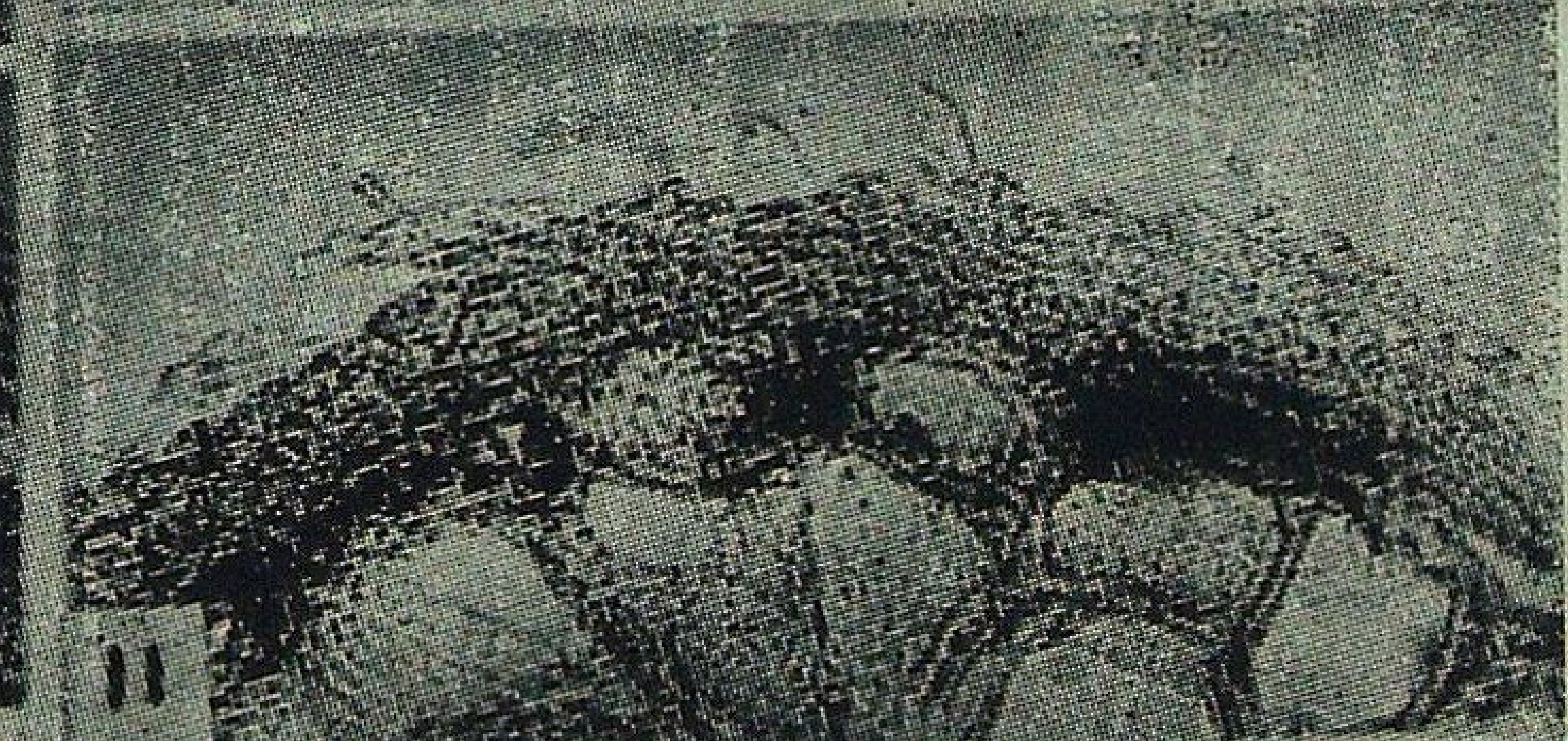
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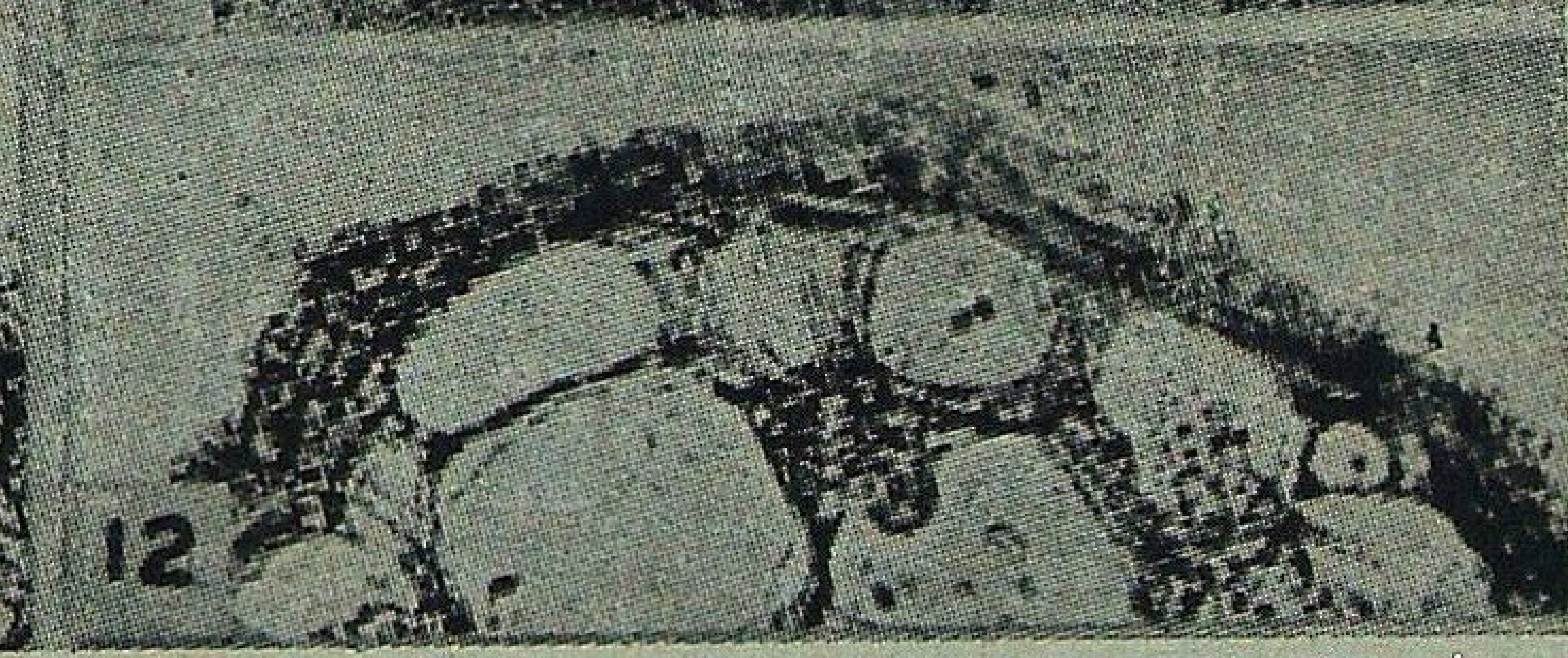
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Plate

Explanation of Figures

Figs. 1–12. Histology of Mycorrhiza.

1. *Pinus kesiya* Mantle, Pseudoparenchymatous with a golden brown peripheral layer. ×525
2. *P. roxburghii* Mantle pseudoparenchymatous with radiating hyphae knobed at apex. (Mycorrhizal Bank) ×400.
3. *P. caribaea* Mantle mycelial, smooth. (Kolli Hills Nursery) ×400.
4. *P. caribaea*, *P. greggii* & *P. michochana* Mantle mycelial-pseudoparenchymatous with projecting hyphae knobed at apex. (Araku & Koraput Nursery) ×525.
5. *P. oocarpa* Mantle loose mycelial with heavy intracellular infection. (Kalinga Nursery) ×400.
6. *P. patula* Mantle loose mycelial. (Gundar Plantation) ×400.
7. *P. kesiya* Mantle pseudoparenchymatous, cells broadly pentagonal (Koraput Nursery) ×525.
8. *P. kesiya* Mantle pseudoparenchymatous with a golden brown peripheral layer. (AP Nursery) ×350
9. *P. kesiya* Mantle pseudoparenchymatous, compact smooth with occasional radiating hyphae. (Koraput Plantation) ×525.
10. *P. kesiya* Mantle loose hyphal. (Mycorrhizal Bank, Anjodha) ×400.
11. *P. kesiya* Mantle mycelial with clamped hyphe. (Kalinga Nursery) ×400.
12. *P. kesiya* Mantle short cellular, rudimantry. (Kalinga) ×400.